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*THE PHILOSOPHY OF HYPER-SPACE.**

THERE is a region of mathematical thought which might be called the fairyland of geometry. The geometer here disports himself in a way which, to the non-mathematical thinker, suggests the wild flight of an unbridled imagination rather than the sober sequence of mathematical demonstration. Imaginative he certainly does become, if we apply this term to every conception which lies outside of our human experience. Yet the results of the hypotheses introduced into this imaginary universe are traced out with all the rigor of geometric demonstration. It is quite fitting that one who finds the infinity of space in which our universe is situated too narrow for his use should, in his imaginative power, outdo the ordinary writer of fairy tales, when he evokes a universe sufficiently extended for his purposes.

The introduction of what is now very generally called hyper-space, especially space of more than three dimensions, into mathematics has proved a stumbling block to more than one able philosopher. The question whether a fourth dimension may possibly exist, and whether it can be legitimately employed for any mathematical purpose, is one on which clear ideas are not universal. I do not, however, confine the term 'hyper-space' to space of more than

*Address of the President before the American Mathematical Society, December 29, 1897.

three dimensions. A hypothesis which is simpler in its fundamental basis, and yet seems absurd enough in itself, is that of what is sometimes, improperly I think, called curved space. This also we may call hyper-space, defining the latter in general as space in which the axioms of the Euclidean geometry are not true and complete. Curved space and space of four or more dimensions are completely distinct in their characteristics, and must, therefore, be treated separately.

The hypothesis of a fourth dimension can be introduced in so simple a way that it should give rise to no question or difficulty whatever. Indeed, the whole conception is so simple that I should hardly deem it necessary to explain the matter to a professional mathematical student. But as we all have to come in contact with educated men who have not had the time to completely master mathematical conceptions, and yet are interested in the fundamental philosophy of our subject, I have deemed it appropriate to present the question in what seems to me the simplest light.

The student of geometry begins his study with the theory of figures in a plane. In this field he reaches certain conclusions, among them that only one perpendicular can be drawn to a line at a given point, and that only one triangle can be erected with given sides on a given base in a given order. Having constructed this plane geometry, he passes to geomety of three dimensions. Here he enters a region in which some of the propositions of plane geometry cease to be true. An infinity of perpendiculars can now be drawn to a given line at a given point, and an infinity of triangles can be constructed on a given base with given sides. He has thus considered in succession geometry of two dimensions, and then passed to geometry of three dimensions. Why should he stop there? You reply, perhaps, because there are only three dimensions in actual space. But in making hypotheses we need not limit ourselves to actualities; we can improve our methods of research, and gain clearer conceptions of the actual by passing outside and considering the possible.

For logical purposes there is no limit to the admissibility of hypotheses, provided we consider them purely as hypotheses, and do not teach that they are actual facts of the universe. It is, therefore, perfectly legitimate to inquire what our geometry would be if, instead of being confined to three dimensions, we introduced a fourth. Many curious conclusions follow. When we are confined to a plane a circle completely bounds a region within the plane, so that we cannot pass from the inside to the outside of the circle without intersecting it. Beings conscious only of two dimensions and moving only in two dimensions, and placed inside such a material circle, would find themselves completely imprisoned, with no possibility of getting outside. But give them a third dimension, with the power to move into it, and they simply step over the circle without breaking it. They do not have to even touch it. Living, as we do, in space of three dimensions, the four walls, pavement and ceiling of a dungeon, confine a person so completely that there is no possibility of escaping without making an opening through the bounding surface. But give us a fourth dimension, with the faculty of moving into it, and we pass completely outside of our three dimensional universe, by a single step, and get outside the dungeon as easily as a man steps over a line drawn on the ground. Were motion in the fourth dimension possible, an object moving in that dimension by the smallest amount would be completely outside of what we recognize as the universe, and would, therefore, become invisible. It could then be turned around in such a way that on being brought

back it would be obverted, or appear as in a looking glass. A man capable of such a motion would come back into our sight similarly obverted, his left side would now be his right, without any change having taken place in the relative positions of the particles of his body. The somerset he would have turned would have completely obverted every atom and molecule of his body without introducing any disturbance into its operations.

This possibility of obversion brings in a curious question concerning the rigor of one of the fundamental propositions in elementary geometry. Euclid proves by superposition that the two triangles in a plane having two angles and the included side equal are equal to each other. In the demonstration it is assumed that the triangles can be made congruent by simply placing one upon the other without taking it out of the plane. From this the conclusion is drawn that the same conclusion holds true if one of the triangles be obverted. But in this case they cannot be brought into congruence without taking one of them out of the plane and turning it over. The third dimension is thus assumed in geometry involving only two dimensions.

Now consider the analogous case in space. Two pyramids upon congruent bases may be proved equal by bringing them into congruence with each other. But suppose that they differ only in that one is the obverse of the other, so that they could be brought into congruence only by looking at one of them in a mirror and then placing the other into congruence with the image of the first as seen in the mirror. Would we detract from the rigor of the demonstration by assuming the possibility of such an obversion without changing the volume of the pyramid? With a fourth dimension we should have no detraction from rigor. We would simply obvert the pyramid as we would turn over the triangle.

The question of the fourth dimension as a reality may be considered from two points of view, its conceivability and its possible objective reality. If by conceivability we mean the power of being imaged in the mind it must be admitted that it is absolutely inconceivable. We have no difficulty in forming a visual conception of three lines passing through the same point, each of which is at right angles to the other two. Such is the familiar system of coördinate axes in space. But he who would conceive a fourth dimension must be able to imagine a fourth axis perpendicular to all three of the others. This clearly transcends all possibility even of imagination. The fourth dimension in this sense is certainly inconceivable.

The question of the objective possibility of the fourth dimension is quite a distinct one from that of its conceivability. The latter limitation upon our faculties grows out of the objective fact that we and our ancestors have had no experience of a fourth dimension; that we have always lived in a universe of three dimensions only. But we should not too readily conclude that all being is necessarily confined to these three dimensions. Those who speculate on the possible have taken great pleasure in imagining another universe alongside of our own and yet distinct from it. The mathematician has shown that there is nothing absurd or contradictory in such a supposition. But when we come to the question of physical fact we must admit that there appears to be no evidence of such a universe. If it exists, none of its agencies intrude into our own universe, at least in the opinion of sober thinkers. The intrusion of spirits from without into our world is a favorite idea among primitive men, but tends to die out with enlightenment and civilization. Yet there is nothing self-contradictory or illogical in the supposition. The fish that swims the

ocean experiences objects which, to him, seem to come from outside his universe, steamships for example. If our atmosphere had been opaque to the rays of light from the sun, or even if it had been so filled with clouds and vapor that we could never see outside of it, we also should have had a similar experience. But we may be said, in a certain sense, to see through the whole of our conceivable space with the aid of our telescopes, and the general tendency of scientific thought at the present time is toward the conclusion that no natural agency of which we can trace the operation originates outside the space into which our telescopes may penetrate. Our universe forms, so to speak, a closed system. This is true apparently even of agencies so subtle as those which give vibrations to ether. If there is any agency which we could imagine to connect us with an outside sphere it is certainly the luminiferous ether. But should this ether enter into a fourth dimension the intensity of light and radiant heat would diminish as the cube of the distance and not as the square. To speak more accurately, radiance emanating from an incandescent body would be entirely lost—would pass completely out of our universe. The fact that it is not lost, and indeed the general theory of the conservation of energy, shows that there is no interchange of energy between our universe and any possible one lying in another dimension of space.

We may regard the limitations of the dimension of space to three as expressing in a certain way a physical fact. Our conception of space is originally based upon the possibility of motion. The threefold posibility of relative motion can be reduced to a physical fact in this way. Let a point be fixed at one end of a rod, the other end of which is immovably fixed to a wall. The point can then have motion over the surface of a sphere whose center is at the fixed point and whose radius is the length of the rod. Now fix one end of a second rod to another point of the plane and bring the two ends of the rods together, and fix the point on both ends; then the point can only move in a circle. Fasten it to a third point of the plane with a third rod, and it cannot move at all. But if we add a fourth dimension it could move.

The limits of space are for us simply the limits of possible motion of a material body. We can imagine a body coming from any point in three dimensional space to us, but cannot imagine one coming from outside of such space, until we add a fourth dimension.

Our conclusion is that space of four dimensions, with its resulting possibility of an infinite number of universes alongside of our own, is a perfectly legitimate mathematical hypothesis. We cannot say whether this conception does or does not correspond to any objective reality. What we can say with confidence is that if a fourth dimension exists, our universe and every known agency in it is, by some fundamental law of its being, absolutely confined to three of the dimensions. But we must not carry a conclusion of this sort beyond the limits set by experience. When we say that experience shows that not only our material universe, but all known agencies in it, are, by a law of their being, incapable of motion in more than three dimensions we must remember that the conclusion applies only to those motions which our senses can perceive, the motions of masses, in fact. There is no proof that the molecule may not vibrate in a fourth dimension. There are facts which seem to indicate at least the possibility of molecular motion or change of some sort not expressible in terms of time and three coördinates in space. If we consider those conceptions of mechanics which we derive from visible phenomena to afford a sufficient explana-

tion of molecular action we must admit that, when the position and motion of every atom of a given substance are defined, the chemical properties of that substance are completely determined. If we take two collections of atoms of the same substance, put them together in the same way, and endow them with the same kinds of vibratory motion, we ought, on any mechanical theory of matter, to obtain substances of identical properties. Now, there seem to be reasons which I cannot stop at present to develop that might make us believe in changes of properties and attributes of substances not completely explained by molecular changes. That such is the case with vital phenomena can be demonstrated beyond doubt; that it is the case with chemical phenomena when they approach the vital character seems very probable. Certainly there is some essential difference between that form of molecular motion in which heat is commonly supposed to consist and the motion of masses. Perhaps the most remarkable of these differences consists in the relation of this motion to the ether. The motion of a mass suffers no resistance by passing through the ether with the highest astronomical velocities. Matter so rare as that of the diffuse comets may move around the sun with a speed of many miles per second without suffering the smallest resistance from the ether—in a word, without any friction between the matter and the ether. But when the molecules have the motion of heat, that motion, if motion it be, is always communicated to the ether, and is radiated away from the body, which thus becomes cool. Whatever form we attribute to the energy of heat, it is certainly a form which is constantly communicated from matter to the ether by a fundamental law of matter. Consequently, if heat be really a mode of motion, as is now generally supposed by physicists, it follows that there is some essential difference between the character of this motion and the motion of the smallest masses into which matter can practically be divided. The hypothesis of vibration in the fourth dimension merely suggests the possibility that this kind of motion may mark what is essentially different from the motion of masses. Of course, such an hypothesis as this is not to be put forward as a theory. It must be worked out with mathematical rigor, and shown to actually explain phenomena before we assign it to any such rank.

I cannot but fear that some confusion on this subject is caused by the tendency among both geometers and psychologists to talk of space as an entity in itself. As I have already said, a fourth dimension in space is nothing more than the addition of a fourth possibility of motion to material bodies. The laws of space are only laws of relative position. Certain fundamental axioms are derived from experience, not alone individual experience, perhaps, but the experience of the race, giving rise to hereditary conceptions born in the mind and corresponding to the facts of individual experience. A tree confined to one spot, even if it had eyes to see and a brain to think, could never have a conception of space. For us the limits of space are simply the limits to which we can suppose a body to move. Hence when space itself is spoken of as having possible curvatures, hills and hollows it seems to me that this should be regarded only as a curvature, if I may use the term, of the laws of position of material bodies in space. Clifford has set forth, with great acuteness and plausibility, that the minute spaces occupied by the ultimate atoms of matter may, in this respect, have properties different from the larger space which alone makes itself known to our conceptions. If so, we should only regard this as expressive of some different law of motion, or, since motion is only change of position, of some

different law of position among the molecules of bodies.

This consideration leads us to a possible form of space relations distinct from those of our Euclidean geometry, and from the hypothesis of space of more than three dimensions, I refer to what is commonly known as 'curved space.' The history of this conception is now so well known to mathematicians that I shall mention it only so far as is necessary to bring it to your minds. The question whether Euclid's axioms of parallels is really an independent axiom, underivable from the other axioms of geometry, is one which has occupied the attention of mathematicians for centuries. Perhaps the simplest form of this axiom is that through a point in a plane one straight line and no more can be drawn which shall be parallel to a given straight line in the plane. Here we must understand that parallel lines mean those which never meet. The axiom, therefore, asserts that through such a point we can draw one line which shall never meet the other line in either direction, but that if we give this one line the slightest motion around the point in the plane it will meet the other in one direction or the opposite. Thus stated, the proposition seems to be an axiom, but it is an axiom that does not grow out of any other axioms of geometry. The question thus arising was attacked by Lobatchevsky in this very conclusive manner. If this axiom is independent of the other axioms of geometry then we should be able to construct a self-consistent geometrical system, in conformity to the other axioms, in which this axiom no longer held. The axiom of parallels may be deviated from in two directions. In the one it is supposed that every two lines in the plane must meet; no line parallel to another can be drawn through the same point in the plane. Deviating in the other direction we have several lines drawn through the point which never meet the given line; they diverge from it as lines on an hyperboloid may diverge.

That such possibilities transcend our ordinary notions of geometrical relations is beyond doubt, but the hypothesis of their possibility is justified by the following analogy. Let us suppose a class of beings whose movements and conceptions were wholly confined to a space of two dimensions as ours are to a space of three dimensions. Let us suppose such beings to live upon or in a plane and to have no conception of space otherwise than as plain extended space. These beings would then have a plane geometry exactly like ours. The axiom of parallels would hold for them as it does for us. But let us suppose that these beings, without actually knowing it, instead of being confined to a plane, were really confined to the surface of a sphere, a sphere such as our earth, for example. Then, when they extended their motions and observations over regions so great as a large part of the earth's surface, they would find the axiom of parallels to fail them. Two parallel lines would be only two parallel great circles, and though each were followed in a direction which would seem to be invariable they would be found to meet on opposite sides of the globe. The suggestion growing out of this consideration is: May it not be possible that we live in a space of this sort? Or, to use what seems to me to be the more accurate language: May it not be that two seemingly parallel straight lines continued indefinitely would ultimately meet or diverge? The conceptions arising in this way are certainly very interesting. If the lines would meet it can easily be shown that the total volume of all space is a finite quantity. The sum of the three angles of a triangle extending from star to star would then be greater than the sum of two right angles. Equally legitimate is the hypothesis that it would

be less than three right angles, but in this case the total volume of space would still be infinite. Now, this is an hypothesis to be tested by experience. Unfortunately, we cannot triangulate from star to star; our limits are the two extremes of the earth's orbit. All we can say is that, within those narrow limits, the measures of stellar parallax give no indication that the sum of the angles of a triangle in stellar space differs from two right angles. If our space is elliptical, then, for every point in it—the position of our sun, for example—there would be, in every direction, an opposite or polar point whose locus is a surface at the greatest possible distance from us. A star in this point would seem to have no parallax. Measures of stellar parallax, photometric determinations and other considerations show conclusively that if there is any such surface it lies far beyond the bounds of our stellar system.

Such are the considerations by which it seems to me that speculations on this subject may legitimately be guided. The wise man is one who admits an infinity of possibilities outside the range of his experience, but who in considering actualities is not decoyed by the temptation to strain the facts of experience in order to make them accord with glittering possibilities. The experience of the race and all the refinements of modern science may be regarded as showing quite conclusively that, within the limits of our experience, there is no motion of material masses in the direction of a fourth dimension, no physical agency which we can assume to have its origin in regions to which matter cannot move, when it has three degrees of freedom. Claiming this, we must carry the claim only to the limits justified by actual experience. We have no experience of the motion of molecules; therefore we have no right to say that those motions are necessarily confined to three dimensions. Perhaps the phenomena of radiation and electricity may yet be explained by vibration in a fourth dimension. We are justified by experience in saying that the space relations which we gather from observation around us are valid for the greatest distances which separate us from the most distant stars. We have no right to extend the conclusion further than this. We must leave it to our posterity to determine whether, in either way, the hypothesis of hyper-space can be used as an explanation of observed phenomena.

S. NEWCOMB.

REPORT UPON SOME PRELIMINARY EXPERIMENTS WITH THE RÖNTGEN RAYS ON PLANTS.

SINCE it is a matter of some interest to know what influence, if any, the Röntgen rays would exercise on plants, I undertook a series of somewhat extensive preliminary experiments, to determine what lines of investigation might profitably be carried on should there be marked indications of any response to possible stimuli from this source.

The lecture room of our botanical department being connected by separate electric wire for the stereopticon, and the wire passing within a few metres of the end of one of the houses of the (*botanical*) conservatory, the current could be connected with the apparatus in the glass house with little trouble and expense. The connecting of the electric wires with the house was done under the direction of Professor H. J. Ryan, of the Sibley College of Mechanic Arts. An ordinary tin frame rheostat and an App's Coil were loaned by Professor E. L. Nichols, of the physical department, and the Crookes tubes used were of a pattern recommended by Professor Nichols, who, at the beginning of the experiment, set up the apparatus. To him I am indebted also for advice concerning the use of the apparatus, and also to Professor E. Merritt, of the physical department.

The portion of the conservatory employed for the experiments was the north end of one of the houses, where a bench space of about 2m. x 3m., and the height of the house, was enclosed as a dark room, by hanging black canton flannel and covering this on the outside and on the roof of the house with coarse cloths or board frames to exclude the light.

Experiment 1. Since in a number of cases the use of the Röntgen ray for exploring internal parts of the human body has resulted in certain injuries which are supposed to be due to some action of the ray, the first of the series of experiments which I conducted with plants was for the purpose of ascertaining if there was any marked injury which could be induced by an exposure of about one hour's time. Indeed, those with whom I discussed the matter prior to the investigations, and who were familiar with the use of the rays for other purposes, were inclined to think that distinct injuries would be produced. For the first experiment a potted Caladium about 60 cm. high was used. One leaf was supported directly in front of the bulb and about 10 cm. distant, while a flat metal key was suspended over the center of the leaf to intercept the rays at this point. The light was turned on at 11:07 a. m., June 6th, and a continuous run was made of 1 hr. 18 mins., *i. e.*, until 12:25 p. m. There was no visible effect at the close of the exposure and subsequently the leaf remained to all appearances normal.

Experiment 2. For the next experiment seedlings of corn, oats, German millet, sunflower and radish, which had been germinated in small 2-inch pots a few days before were used. The seedlings varied from 5 to 10 cm. in height. The pots were placed directly in front of the bulb, in such a manner that each kind of seedling was situated at different distances from the bulb in a radiating row. The experiment started at 1 p. m., June 6th. A piece of black canton flannel was tied over the bulb to intercept the electric light rays, so that their influence would not be felt, and this was kept over the bulb during all the subsequent experiments. At 2:45 p. m. it was noticed that the plants nearest the bulb were so close that electrical discharges took place between the bulb and the leaves, causing the plants to nod constantly toward the bulb and even to come sometimes in contact with it as the spark was formed. They were then moved to a distance of 15–20 cm. At nearly 4 p. m. all the plants were removed for a period of about three minutes while exposures were being made to obtain photographs. With this exception the seedlings were exposed to the influence of the Röntgen ray for a period of ten hours, the run being made from 1 p. m. to 11 p. m., when the dynamos were shut down for the night. No injurious effect was noticeable nor could any be detected later.

Experiment 3. The next experiment was started at 6 p. m., on June 6th. For this were used seedlings of corn, wheat, sunflower, radish, German millet and soja bean. The seedlings were grown in a dark room and were, therefore, etiolated, and varied from 8 cm. to 20 cm. in height. The plants were exposed that evening continuously for five hours. The wheat, German millet and corn seedlings were so frail that they drooped in various directions. At 9 p. m. it was noticed that the seedlings of the soja bean were turned slightly toward the bulb, while at the beginning of the experiment they were turned away from it. No perceptible injury took place.

Experiment 4. A potted begonia plant was placed so that the delicate flowers hung in front of the bulb within 10 cm. and remained there for five hours. There was no perceptible injury at the close of the run; nor on any subsequent days could injurious effects be observed.

Experiment 5. A potted plant of Caladium was placed with the leaf within 20 cm., with a small piece of sheet lead so placed between it and the bulb as to intercept a portion of the rays. The exposure continued for five hours. At the close of the experiment, and subsequently, no change could be observed.

Experiment 6. On June 8th a large number of seedlings which had been started previously in soil contained in wooden trays were placed in front of the light and exposed for several days. The seedlings used were those of corn, oats, wheat, radish, sunflower, soja bean, white lupine, cucumber, vetch, pea, German millet and cotton. There were several duplicate sets of the seedlings for this experiment; one lot was planted June 1st and the other June 5th, to provide seedlings in different stages of growth. From some which were just germinating they ranged in size to those which were 10 cm. high. The following gives the facts concerning the condition of the seedlings on June 8th, at the time of starting the experiment:

LOT 1. PLANTED JUNE 1ST.

NAME OF PLANT.	CONDITION JUNE 8TH.
Sunflower	5—8 cm.
Wheat	8—10 cm.
German millet	3 cm.
Nonpareil bean	just coming through the soil.
Soja bean	5 cm.
Cotton	just coming through the soil.
Oats	8—10 cm.
Corn	5—8 cm.
Vetch	5—8 "
Pea	2—5 "
Cucumber	2—4 "

LOT 2. PLANTED JUNE 5TH.

NAME OF PLANT.	CONDITION JUNE 5TH.
Cotton	germinating.
Wheat	germinated.
Sunflower	nearly up.
German millet	germinated.

The boxes containing the seedlings were so arranged that some of the seedlings were very near the bulb, while others were at varying distances, to the front, and right and left, so that if any distinct influence was manifested the extent of the field of this influence could be easily determined, and its degree, to some extent, be measured by the effect on the plants at varying distances. The field was explored with a fluoroscope to be certain that the rays reached all the plants which were placed in front of a line a few centimetres in advance of the bulb. A check lot of the seedlings was placed behind the instrument in the dark room in which the experiments were being conducted, so that they might grow under exactly the same conditions, except that they would not be under the influence of the Röntgen rays.

The experiment was started at 11 a. m., June 8th. The run was continued until 11 p. m., but since the interrupter in connection with the coil did not work satisfactorily the circuit was permanently broken at intervals. During this period the current was on about one-half the time. The following day, June 9th, the interrupter continued to work unsatisfactorily, and finally broke down at 5 p. m., the current having been turned on at 8 a. m. During the day of June 9th the instrument was running about one-fourth of the time. The interrupter was repaired and the current was started again at 10:20 a. m., the following morning, June 10th, and a continuous run was made up to 11 p. m., June 11th, the run was continuous from 8 a. m. until 11 p. m., and on June 12th, Saturday, from 8 a. m. to 4:30 p. m., when this experiment was discontinued.

During all of this time the plants behaved exactly as one would expect them to in an ordinary dark room. Those which had not come above the soil before they were placed under the influence of the Röntgen rays were entirely etiolated, while the new growth of shoots and leaves on

those which had attained some growth before the beginning of the experiment was also etiolated, the shoots being slender and the leaves small. The leaves, which were green at the start, gradually became nearly or quite yellow. The wheat, oat and millet seedlings were so weak that they fell prostrate, lying in all directions. At times it appeared as if the rays might have some peculiar taxic influence, since some of the seedlings were turned, now in one direction and at a later time in another, but there was no constancy in any of these movements, and they were ascribed to nutation. In fact, seedling plants which were in the path of the Röntgen rays for a period of over forty-five hours during five days did not at the close of the experiment appear in the least different from those in the same dark room, but which were out of the reach of the rays, and there was no appreciable difference in behavior during the continuance of the experiment.

That the seedlings were susceptible to directive influences of ordinary daylight was shown by their behavior when the dark compartment was opened. At one time the compartment was opened by parting two of the hanging dark curtains for about two minutes. Two hours afterward, when the compartment was again opened, nearly all the plants were turned strongly toward this point. This appears to me to be an interesting illustration of the great sensitiveness of these etiolated plants to light, and proves the fact that the response to the stimulus occurs some time subsequent to the stimulus.

The plants used in this experiment were now placed in normal light, and were observed carefully for several days. All of the etiolated plants gradually became green, but it was noticeable that those which were not under the influence of the Röntgen rays recovered more rapidly, though the difference was not very striking. This suggests that there may be some subtle injurious influence on the chloroplastids of the plant.

Experiment 7. The next experiment was started on June 14th, at 9 a. m. The dark cloth had been removed for the purpose of growing seedlings under the Röntgen rays which were at the same time exposed to normal daylight. The seedlings were arranged in front of the bulb in the same way as described for experiment 6. The following seedlings were used: squash, wheat, oats, pea, vetch, cow pea (*Dolichos*), sunflower, radish, soja bean, nonpareil bean and cotton. The seeds were planted a few days in advance, so that they were just coming through the ground in various stages when the experiment was started. A run of fourteen hours was made on June 14th, and of nine hours on June 15th, when this experiment terminated. No influence whatever from the Röntgen rays was observed.

In 1896 Schober* published the results of some experiments with the Röntgen rays on seedlings; these were undertaken for the purpose of determining if short exposures to the rays would produce taxic movements in the nature of curving or bending of the seedlings. Young oat seedlings were used which had been germinated in a dark room, and they were enclosed in a small geotropic chest, blackened both on the inner and outer side. This was so placed that they were at a distance of two cm. from the bulb at the opening of the chest. They were exposed for one half hour, and after a short interruption for another half hour. No turning had taken place. In order to see if the seedlings were sensitive to the light they were then placed near a small opening in the side of the room, and in the course of an hour perceptible heliotropic movements began, which were more marked

*Schober, A. Ein Versuch mit Röntgen'schen Strahlen auf Keimpflanzen. Ber. d. deutsch. Bot. Gesell. XIV., 108–110, 1896.

at the close of two hours, when they stood at an angle of 60°. He concludes from his experiments that the Röntgen rays have no taxic influence on seedlings.

Experiment 8. Three species of Mucor were sown in dilution cultures in nutrient agar-agar, in Petrie dishes. After the spores had begun to germinate one culture of each was placed within 25 cm. of the bulb, and the rays were then intercepted from one-half of each culture by a piece of sheet lead. A duplicate set of the cultures was placed out of reach of the rays. The cultures were exposed for four hours, and returned to the culture room. No difference in growth was perceptible, the Röntgen rays neither inhibiting nor hastening growth.

Experiment 9. Several forms of chromogenic bacteria were then subject to the influence of the rays. Several tube cultures in nutrient agar-agar were placed within 10 cm. of the bulb for about four hours. A duplicate set was kept in the same house, but outside of the field covered by the Röntgen rays. From each of the two sets of cultures inoculations were made into fresh nutrient media. There was no perceptible difference in growth nor in the color as a result of the exposure to the rays.

Experiment 10. A motile bacillus, *B. communis*, was next placed within 15 cm. of the bulb. The cultures were made in bouillon and poured into Petrie dishes. Two Petrie dish cultures were employed, and the rays were intercepted from one-half of each by sheet lead. They were exposed six hours. From each half of the two cultures then one drop was carried to the third dilution, and four cultures were then made from each of the second and third dilutions in nutrient agar, and distributed in Petrie dishes in order to compare the number of colonies. The results showed no difference in the proportionate number of bacilli in the two halves of the Petrie dishes. The rays, therefore, have no influence on the distribution of the bacilli in the liquid, nor on their vitality for the length of time exposed, a fact which Professor Marshall-Ward had already demonstrated.

Experiment 11. A species of motile Oscillatoria was distributed in six watch glasses with a small amount of water, the threads being arranged in a tangled mass in the center. Two of these were placed within 8 cm. of the bulb, two others at a distance of 20 cm. with the Röntgen rays intercepted by sheet lead, and the other two placed outside of the dark room. The experiment began at 12:30 p. m. and was discontinued at 4:30 p. m. In all the vessels during this period of four hours the threads moved out in a radiating fashion from the center, and some had moved partly up the sides of the vessels. In one of those exposed to the influence of the rays the thread had moved farther than in any of the others, while in the other five vessels no difference in the extent of the movement was observed, and the greater movement of the threads in one of the two exposed to the rays could probably be accounted for on other grounds.

Experiment 12. The influence of the rays was next tested on sensitive plants, *Mimosa pudica*, grown in pots. Two plants were used, and both were jarred, so that the leaves dropped on their petioles and the leaflets closed in pairs. The larger one, *a*, was placed so that the nearest leaves were within 10 cm. of the bulb after the dark room had been dispensed with. The smaller one was placed in another portion of the same house, but where the daylight was of the same intensity, so far as the eye could judge. In twenty minutes the leaves of the two plants had opened somewhat, but *b* had opened more than *a*, which was within the field of the rays. The plants were then jarred a second time, and inter-

changed, *b* being placed under the rays. Ten minutes later *b* had opened slightly, while *a* had not opened at all; the sun by this time, 6 p. m. (June 12th), having passed below the top of a western building. While I intended at the time to repeat this experiment on the following day, the result shows quite conclusively, I think, that the difference manifested by these two plants in the rapidity of opening was due to individual peculiarities rather than to any influence of the Röntgen rays. For while it would at first appear that they exercised a slight inhibitory influence, the interchange of the plants shows that this was due to the more rapid response of the plant *b* to the influence of daylight.

In Schober's experiments the question as to whether the seedlings, or any parts of the plant, readily absorbed the Röntgen rays was not studied. From time to time, during the continuance of my own experiments, the field was explored with the fluoroscope to be certain that the rays were being evolved, and also an occasional photograph of the hand was made as a test of the strength of the rays. Good photographs were thus obtained with an exposure of from four to five minutes at a distance of 20 cm. to 25 cm. During the close of the first week's experiments the Crookes tube gradually deteriorated because of the high vacuum produced by prolonged use. This was first manifested in the resistance offered by the tube to the passage of the electric current. It was also manifested in some of the photographs taken at the time, the plates being affected unevenly, which indicated that the rays were given off more strongly in some directions than others. This bulb was discarded on June 12th, and a new one substituted on June 14th. Since it is well known that the Röntgen rays pass quite readily through wood the non-absorption of the rays by the plants might explain the absence of any marked influence upon them. Consequently, this subject received some attention, and attempts were made to obtain Röntgen photographs of some of the plants experimented upon, as well as of some other plant parts. The greater number of the exposures were made by placing both the sensitive plate and the object inside an ordinary card box, in which the plates are sold, a thin sheet of white paper being placed between the sensitive film and the object. A plate of a high sensitometer was used.

The first object used was an oak leaf (*Quercus rubra*). This was exposed, first for four minutes and a second time for three minutes. The leaf selected was a rather young and succulent one, thus being more difficult to photograph by transmitted light, but the older and firmer ones were too large for the size of plate used. The oak leaf was exposed for a longer time than would have been necessary if the method employed for a majority of the photographs, described above, had been followed in this case. Here, however, an ordinary plateholder was used, and a black rubber slide not only lay over the plate, but another was placed over the leaf, which was on the outside, to hold it in place. While in both of these cases an outline of the leaf and of the more prominent veins was obtained, better results were had when the exposure was made in an ordinary cardboard box. Here a fairly good outline of the leaf and of its venation was obtained. It is also to be observed that in the shorter exposure, which is needed for these delicate objects, a picture is also obtained of the structure of the box, the thin paper which is pasted on the outside, and overlaps the edges, showing quite plainly. Röntgen photographs of five seedlings which had for several days been under the influence of the rays were made. These were cotton, pea, nonpareil bean and soja bean, the cotton and one of the nonpareil

bean seedlings being grown entirely under the rays. Good outlines of the leaves and tracings of the principal veins were obtained, while the stems, roots and cotyledons of the pea and beans made strong pictures. The contrast between the general groundwork of the leaves and the surrounding space is quite strong, which shows that there was considerable absorption of the Röntgen rays even by the delicate seedlings experimented upon, and that the absence of any marked injury or other influence could not be due to non-absorption of the rays.

The other plant parts which were photographed by the Röntgen rays are the following: Leaves of two species of Begonia, in which quite strong pictures of the leaves and of the venation were obtained. The venation of B, rex, with rather prominent red veins coming out more strongly than B, nitida-alba, both were being taken on the same plate. The interior of various nuts, as almond, peanut, hickorynut, makes quite strong pictures. Good pictures were obtained of the endosperm (prothallium), of the fruit of cycas, also of the seeds of green peas and beans still within the pod. Flower buds of Fuschia show the pistill and stamens in position before opening and the delicate flowers of Begonia also absorb the rays sufficiently to be photographed, although the picture made was weak. Fruits of apricot and green fruit of the plum and pea absorb the rays so strongly that it is difficult to get a good contrast between the flesh and stone, while the ripe fruit of a black cherry (probably a variety of *Prunus avium*) gives better contrast. The placenta and young ovules of *Podophyllum peltatum* show rather indistinctly through the walls of the ovary. A knot in the pine board makes a distinct Röntgen photograph. The spadix and flowers of *Arisæma triphyllum* show distinctly through the spathe, and the vascular ducts of the stem are also photographed. In specimens of Peltandra, in which the spadix was entirely enclosed within the spathe the spadix and outlines of the staminate and pistillate flowers are quite distinctly shown in a Röntgen photograph, while the vascular ducts of the stem show quite strongly in the picture (see Plate I., Frontispiece).

It is thus seen that plant tissues absorb the Röntgen rays quite freely, and it is singular that there is not a more marked influence on growing parts, especially that there are no visible external injuries, even when the parts are exposed at close range a large part of the time during several days, since the general impression is that the rays, even with comparatively short exposures, are injurious to the human tissues.

The longer my experiments continued the more mysterious the whole subject seemed. On a dark night, when the electric-light rays were intercepted by a black screen, exploring the field with a fluoroscope there was an abundance of light, flashing and quivering with the variations in the electric transmission through the tube, penetrating, and yet capable of absorption to a considerable degree. That it should present no easily discernible influence for the time during which the work continued was cause for profound surprise.

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*SOME CONSIDERATIONS UPON THE FUNCTIONS OF STOMATA.**

THE sporophytes of many Bryophyta and of all Pteridophyta and Spermatophyta have their epidermis pierced with minute openings known as stomata. These occur upon particular portions of the aërial structures, not being found upon roots, nor upon subaqueous stems and leaves. They always stand over masses of chlorophyll-bearing

* Read before Section K. of the British Association for the Advancement of Science, August 19, 1897.

cells, and communicate directly with their intercellular spaces.

Every stoma is more than a mere slit between the epidermal cells. It is, in fact, a simple organ consisting of two active cells, the 'guard cells,' between which is the elongated opening. By changes in shape the guard cells narrow or broaden the opening, or completely close it.

It has been found that gases and water-vapor pass through the open stomata. In the case of gases the passage is in either direction, while it appears that the water-vapor passes in one direction only, namely, from the intercellular spaces outward. From the fact that the stomata serve for the passage of both gases and water-vapor have arisen two views as to their proper function, some botanists holding that they are organs of respiration, that is, breathing pores, while others regard them as transpiration organs, that is, organs for permitting the escape of surplus water from the tissues of the plant. According to the first view the stomata are connected directly with the process of photosyntax and the metabolic changes which follow it, in other words, with the supply of carbon to the plants, while according to the second view they are connected with the supply of inorganic salts to the ash constituents of the plant. Since the passage of water-vapor through the stomata is a much more noticeable phenomenon than the ingress or egress of gases, it is quite natural that at first the former should be considered as the primary function. With this view have come corresponding explanations of the purpose of transpiration, involving much of the discussion of nutrition in the treatises on plant physiology. If stomata are organs of transpiration, then transpiration is a physiological phenomenon of much importance, and it behooves us to find out why plants have developed organs for its promotion.

In considering the questions involved, it is well to remember that terrestrial plants which possess stomata have developed from aquatics none of which have stomata. These aquatics, living in the ocean or the fresh-water rivers and lakes, must supply themselves with all their food constituents from the water and the substances it holds in solution. In the simpler plants every cell absorbs these directly from the surrounding water, and this is true of the larger plants also, with slight modification. We must not, however, overlook the fact that water itself is an indispensable constituent of every cell, not as food, but as a part of its mechanical structure. More than nine-tenths of every active cell is water, upon whose presence the activity of the cell is dependent. In aquatics this necessary water is supplied directly from the surrounding medium, and since there is no loss of water each cell easily maintains all that it requires.

Terrestrial plants must supply their cells with the necessary food constituents, and must, also, maintain in them the proper amount of water. Every cell in a terrestrial plant must be turgid with water in order to be active, and if this be impaired the plant suffers. The maintenance of the water supply is thus of the greatest importance in terrestrial plants. Accordingly, the roots are always in communication with water in the soil from which they obtain their supply. The cells of the stems and leaves must obtain their water by absorbing it from the turgid root-cells. Now, these cells in the stems and leaves not only have no direct access to water, having to obtain their supply indirectly, at second hand as it were, but they are surrounded by a medium which is drier than they, so that they are constantly losing water by evaporation. This loss of water is usually greater than the scanty supply from the water of the soil, and accordingly the aërial parts of plants are protected by a layer of

cuticularized cells, the epidermis. The drier the air in which a plant grows the thicker the epidermal layer, an extreme case occurring in the Burro Thorn (*Holocantha emoryi*) of the arid regions of southern Arizona, where there are from three to five layers of cells in the epidermis. That plants are able to protect themselves against very dry air is shown by the fact that even in excessively dry climates there are many species which are able to live and form flowers and seeds.

But with the change from the aquatic to to the terrestrial habit there came a division of labor in the organs of absorption. The roots now absorb water and solutions, while the stems and leaves absorb carbon dioxide. And here arises a difficulty: The epidermis which prevents the escape of water-vapor also prevents the absorption of carbon dioxide. This difficulty was surmounted by the formation of stomata. A leaf without stomata, or what is the same thing, with its stomata permanently closed as with wax, will not lose water, but it will starve for want of carbon dioxide. These stomata are open as long as there is no danger of such a water loss as would result in loss of turgidity, but when the cells show an approach to flaccidity the stomata close. While open there may be a free interchange of gases, carbon dioxide entering and being absorbed by the chlorophyll-bearing cells, but while this is going on there is certain to be a considerable loss of water, especially if the air be dry. On every dry day land plants lose much water, since they must have their stomata open in order to obtain their supply of carbon dioxide.

Aërial plants, as many Tillandsias and Orchids, do not differ in any essential respect from terrestrial plants. They must have enough water to keep their cells turgid, and, at the same time, their chlorophyll-bearing cells must be supplied with carbon dioxide. They invariably grow in moist climates, where the constant moisture of the air is supplemented by frequent drenching rains. Under such conditions many terrestrial plants would be able to live and grow for some time. At the same time it is to be observed that many aërial plants have a greatly thickened epidermis, or have their surfaces covered by a coat of dry hairs. They evidently have taken some precautions to guard against harmful water loss.

It is not too much to say that the facts cited above indicate that respiration is the normal function of stomata, and that the loss of water through stomata is incidental and secondary. Some experimental results may be cited here.

a. Stahl has shown that when the stomata are closed no starch is made,* showing that the carbon dioxide must enter by the stomata.

b. Blackman concludes that "practically the sole pathway for carbon dioxide into or out of the leaf is by the stomata."†

c. Stahl has shown that transpiration takes place through the stomata, and this only when they are open.‡

d. Observations often repeated by many physiologists show that the stomata of many cultivated plants close quickly when the supply of water to the roots is deficient, and that plants in dry climates have remarkable devices for preventing the loss of water.

e. Stahl has shown§ that in many evergreen plants the stomata close during the period when there is no carbon assimilation.

f. It is a well known fact that stomata are usually open in sunlight, when carbon-assimilation (photosyntax) is possible.

g. Plants from which carbon assimila-

* *Bot. Zeit.*, 52: 127–133 (1894).

† Phil. Trans. Roy. Soc. London, 186, B: 485 (1895); from abstract in *Bot. Gaz.*, 20: 336.

‡ *Bot. Zeit.*, 52: 117–127 (1894).

§ l. c.

tion is absent have greatly reduced numbers of stomata, as in the dodders (Cuscuta) and the little mistletoes (Razoumofskya), while they are present in abundance in green parasites (Viscum and Phoradendron).

From the foregoing rapid and quite summary survey of the different phases of this question we are warranted in concluding:

1. That one of the functions of stomata is the admission of carbon dioxide to the chlorophyll-bearing tissues of the plant, for use in the formation of the carbohydrates.

2. That the loss of water by terrestrial plants was originally hurtful, and is so now in many cases.

3. That if plants have utilized this constant phenomenon it is for the supply of food matters of secondary importance, as the salts in solution in the water of the soil.

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*RECENT PROGRESS IN AGRICULTURAL CHEMISTRY.**

I.

Since the last *résumé* of progress in agricultural chemistry was reported to this body a considerable advance has been made in our knowledge of the methods and means of nitrogen assimilation. The most marked progress has been made along the line of the inoculation of seed and the soil with nitrifying ferments. Much has been done in this direction, and the results of the experiments are sufficiently encouraging to warrant the belief that much good may yet come to agriculture by following out this line of investigation. In 1895, in the Yearbook of the Department of Agriculture, the following statements occur:

"It may not be long until the farmer may apply to the laboratory for particular nitrifying ferments to be applied to such special purposes as are mentioned above. Because of the extreme minuteness of these organisms the too practical agronomist may laugh at the idea of producing fertility thereby, and this idea, indeed, would be of no value were it not for the wonderful facility of propagation which an organism of this kind has when exposed in a favorable environment. It is true that the pure cultures which the laboratory affords would be of little avail if limited to their own activity, and it is alone in the possibility of their almost illimitable development that their fertilizing effects may be secured."

It cannot be said that the prophecies foreshadowed in the above quotation have been fully verified, but at least something has been accomplished.

From the time that it was demonstrated by Hellriegel and Wilfarth that the power which leguminous plants possess of increasing their stores of nitrogen was due to the bacteria inhabiting nodules on their rootlets, the study of this phenomenon has been pushed with great vigor in all parts of the world. Intimately related, as it is, to the nitrifying organisms of the soil, it has, nevertheless, been demonstrated that the two species of bacteria, the general nitrifying species and the special so-called symbiotic species, inhabiting the roots of plants, are entirely different in their nature, and that their activity is not mutually convertible.

The most extensive experiments in the direct inoculation of the soil with nitrifying ferments have been conducted by Dr. Salfeld, of Lingen, in Hanover. The greater part of the experiments has been made on peaty soils, as it is in such soils that the greatest deficiency of nitrifying organisms is observed. An excellent review of Dr. Salfeld's work has been pub-

* Prepared at the request of the officers of Section C, of the A. A. A. S., and read before Section C and the American Chemical Society at the Detroit meeting, August, 1897.

lished by N. H. J. Miller, in the Journal of the Royal Agricultural Society of England, Vol. 7, third series, part 2, pp. 236 *et seq.*

The method employed by Dr. Salfeld was to spread upon the peaty soils large quantities of soils in which peas, beans and other leguminous crops had been grown. Immense quantities of the soil to be used to develop the fertilizing ferments were required; quantities ranging from 16 to 32 hundred weight per acre were used, and it was found that the larger quantities gave the better results.

The particular bacterium which is most active in developing nodules on plants has been called the *Bacillus radicicola*. It was found in Dr. Salfeld's experiments that there exist many peaty soils which are so poor in this bacterium as to require inoculation with other soils containing it before leguminous crops can be grown successfully.

As was to be expected, the most striking results were obtained with soils which were most deficient in the nitrifying bacillus, and when the inoculation was accompanied with the addition of a sufficient quantity of lime, phosphoric acid and potash. The large quantities of soil which are required for the direct inoculation, as outlined above, have rendered of great interest the attempts to secure inoculation in a more direct and positive manner. This has led to a study of the possibilities of securing pure cultures of nitrifying organisms which can be applied directly to the seed before planting, or can be mixed with moderate quantities of soil and thus distributed over a large area.

The most extensive experiments in the processes of seed inoculation have been carried on by Professor Nobbe, of Tharand, Saxony. The principle of these inoculations is first to secure the pure cultures of the bacteria inhabiting the nodules of the roots. These pure cultures are obtained by the ordinary bacteriological processes now so well known. With these pure cultures inoculations of various kinds have been practiced, viz., inoculations of the soil itself, inoculations of the exterior of the seed, and inoculation by pricking the seed with needles bearing the germs of the pure cultures.

The remarkable fact has been developed that while the bacteria derived from the pure cultures of the root nodules of various legumes appear to be microscopically identical they, nevertheless, have very distinct characters. The results of these experiments have shown that in inoculation best results are obtained when plants of the same species and, as nearly as possible, the same family are used. Even among the Leguminosæ, when passed from one species to another, the vitality of the organism is either diminished or entirely destroyed. This is illustrated, for instance, in attempts which have been made to inoculate the members of the pea family with the bacteria taken from the roots of clover, or *vice versa*. The commercial outcome of these experiments is that these cultures have been prepared on a large scale for general sale. While the idea of thus preparing fertilizers in a practically infinitesimal quantity for field work is not a new one, and is not lacking in its appeals to the imagination, it cannot be said that the practical results have been fully equal to the expectations which have been aroused.

The commercial name of these preparations is nitragin, although, etymologically, probably the term nitrogene would have been preferable, but it was necessary to distinguish it in some way from the name of the element.

The Imperial Seed Control Station at Vienna made experiments with 100 kilograms of soil taken from a field where lupines had been grown, and 20 kilograms of analogous soil coming from a field where

serradella had been grown. These soils, which were to be used for inoculation, were taken from portions of the field where the roots were abundantly provided with the usual nodules. The soil selected for inoculation by these samples was sandy, poor in humus and rich in lime with a gravelly subsoil.

The inoculations which were made have shown that the lupines and serradellas, which, up to that time, had never been developed successfully in the fields where the experiments were made, in spite of most careful culture, showed a remarkable growth in comparison with the plots which were not inoculated. The serradella which was inoculated directly with the nitragin did not respond to this inoculation, but peas inoculated with the nitragin showed a remarkably luxuriant development of the plants, with the formation of radical nodules, in comparison with the plants cultivated at the same time and not inoculated. It is necessary, however, that these experiments with inoculation be repeated for several years before definite conclusions in regard thereto can be drawn. (l'Engrais, Vol. 12, 1897, p. 351.)

Experience has shown that preparations of nitragin do not retain their vitality indefinitely and, in order to secure the best results, should be used as soon as possible after manufacture. It is evident also that the particular source from which each sample of nitragin is prepared must be designated, and the farmer wishing to use it as a fertilizer must purchase those varieties which are suited to the crop he wishes to grow; otherwise, he may make the mistake of applying nitragin derived from peas or beans to a clover field, or the contrary.

An excellent review of the methods of preparing nitragin and the processes of its application is given by J. Augustus Voelcker, in the Journal of the Royal Agricultural Society of England, Vol. 7, third series, part 2, pp. 253 *et seq.* The method of obtaining the pure cultures of the nitrifying bacteria is as follows:

A plate of prepared gelatin is inoculated from the nodules of the leguminous plants containing the living bacteria. A second plate is inoculated from one of the colonies formed in the gelatin plate. This process is continued until a pure cultivation is obtained, due to one particular species of nitrifying organism.

In preparing nitragin for commercial use the pure cultivation, obtained as above, is placed in a bottle, holding from 8 to 10 ounces, containing a small quantity of agar gelatin on which it is allowed to grow. The bottle is sealed and the contents kept in the dark. Up to the present time nitragin has been prepared from 19 different kinds of leguminous plants. Each bottle, when sealed, has a different colored label according to the kind of crop it is intended for, and also the German and botanical name of the plant. The contents of a single bottle are sufficient for securing the inoculation on an acre and a-half of land on which the crop is to be grown and are sold for about 65 cents. In appearance, as a rule, the bottle seems to be filled to the depth of one and a-half inches with a light brown jelly in which may be noticed a white growth or mold. Care must be taken that the temperature of the mixture be not raised above blood heat and that the bottle be not exposed for any length of time to strong light. A moderately high temperature and exposure for any length of time to intense light destroy the vitality of the organism.

The nitragin may be used directly on the the seeds which are to be sown, which, on germinating, develop radicles on which the organisms grow. In the inoculation of the seed the contents of the bottle of nitragin are liquefied by gentle warmth and poured into half a liter of lukewarm water. Any

residual jelly in the bottle is dissolved by shaking it with the water. When the jelly has been thoroughly distributed throughout the water the seeds to be inoculated are sprinkled thoroughly and worked well together so that a portion of the moisture is attached to each seed. The seeds are dried by mixing with some fine earth taken from the field in which they are to be sown.

The best method of applying nitragin is to at first introduce it into a sufficient quantity of moist earth, which is subsequently thoroughly stirred from time to time until the organisms have had time to multiply and distribute themselves in great numbers throughout the whole mass. This moist mass, dry enough, however, to permit of its being thoroughly stirred without caking, is applied to the field either by sowing broadcast or in ordinary drills such as are employed in the distribution of fertilizers. While, as has been said, the first effects have not been so good as have been anticipated, there is sufficient evidence to warrant the belief that the use of nitragin may in the near future become commercially valuable. This leads to the hope that we may find speedily verified the prediction which I made some four or five years ago to the effect that the nitrifying organisms of the soil, in the form of reasonably pure cultures, would eventually be used for fertilizing principles. The seeding of the soil with appropriate nitrifying ferments is certain to become as much of an exact science as the use of the proper ferments in butter and cheese making, in the curing and fermentation of tobacco and in other commercial operations where the activity of bacteria conditions the character and value of the product.

Mazé has recently shown that the life of bacteria resident in the nodules of the Leguminosæ is not a pure symbiosis. It has been demonstrated by this investigator that where artificial conditions, suited to the nourishment of these bacteria, are provided, they are able to oxidize free nitrogen in an environment from which all plant life is rigidly excluded. The bouillon in which the bacteria were cultivated was obtained from white beans. To this bouillon 2.5 per cent. of sugar and 1 per cent. of common salt and a trace of bicarbonate of soda were added. The bouillon was solidified by the addition of 15 per cent. of gelose and was spread in layers 4 millimeters thick on the botton of glass dishes about 20 centimeters in diameter. These vases were so disposed as to be supplied with a current of air from which every trace of oxidized nitrogen was removed and which had been subjected to a high temperature for a sufficient length of time to entirely sterilize it. This was accomplished by passing it through a tube containing metallic copper heated to low redness but not high enough to sensibly diminish the content of oxygen in the air. It was then conducted through a tube filled with broken glass saturated with sulfuric acid for the purpose of absorbing any ammonia, next through a bottle containing sterilized distilled water to saturate the air with the vapor of water, whence it passed to the dishes where the cultures were made. In five days it was found that the sugar of the broth was all consumed and that the quantity of oxidized nitrogen in the bouillon had been more than doubled.

Thus it was proved that the bacteria of the Leguminosæ, placed in a medium resembling as nearly as possible that in which they naturally live, are capable of oxidizing free nitrogen without any symbiotic help of any kind. If these deductions of Mazé be verified by subsequent investigators, it will prove that the nodules in which these bacteria reside are only convenient places in which they exercise their activity, which is entirely independent of the vital activity of the plant which they inhabit.

The sources of the first organic nitrogen

suitable to the nourishment of plants have been the subject of investigation in many quarters. It has been established with a considerable degree of certainty that the nitrifying organisms are capable of existing on the surface and even to a considerable depth in the interior of bare rocks at high altitudes where even the mosses and lichens fail to grow. It is evident, therefore, that these organisms have a great deal to do in the incipient stages of vegetable life and in the preparation of the first particles of humus, which is the substance distinguishing soil from finely cominuted rocks. Later investigations show also that nitrogen exists in combination with metals, as metallic nitrids, as has been shown by the investigations of Hillebrand and others. Among other metallic nitrids that of thorium has been detected. Notable quantities of mineral nitrogenous compounds have been found in the carnallit coming from the Stassfurt mines. As much as .018 per cent of ammoniacal nitrogen has been found in these salts. The artificial carnallit is richer in ammonia than that of nature. It is evident that in carnallit the ammonia replaces a small portion of the potash.

In regard to the origin of this ammoniacal nitrogen, it is generally understood that it comes from the decomposition of the living beings which peopled the sea whose evaporation produced the saline deposits. The ammoniacal nitrogen which is present in the primitive rocks, however, cannot be ascribed to this source, since these rocks were formed at an epoch when life did not exist upon the surface of the earth. This ammoniacal nitrogen, as has been said, occurs almost uniformly as metallic nitrids. It was doubtless, therefore, the first form of nitrogen used to nourish the beginnings of animal and vegetable life, since it existed before any of these forms could, by their decomposition, have furnished available nitrogen for plant growth. This ammoniacal nitrogen, therefore, must have served directly to nourish the first forms of life and thus to have helped lay the foundations of the whole vegetable world. (l'Engrais, Mar. 12, 1897; Apr. 9, 1897.)

A heated discussion has arisen between the French and German schools of agriculture in regard to the harmfulness of the denitrifying organisms found in soils and manures. Wagner urges the importance of sterilizing stable manure in order to prevent the loss of nitrogen that would otherwise be brought about by the organisms contained in it. Deherain, on the other hand, declares that this precaution is unnecessary when stable manure is applied to ordinary soils in the usual quantities.

Comparatively little attention has been given to the isolation and study of pure cultures of the nitrate-destroying organisms found in soils, manures, straw and fodders. While their existence has been repeatedly proved and their behavior in mixed cultures has been studied by Gayon and Dupetit, Springer, Deherain and Maquenne, Breal and others, the first denitrifying organisms obtained in pure cultures and accurately described were those reported by Burri and Stutzer in 1895. These investigators found a denitrifying organism in horse manure which they called *Bacillus denitrificans I.*, and which they found to rapidly destroy nitrates when growing in the same culture with *B. coli communis*. They also isolated and described, under the name of *B. denitrificans II.*, a denitrifying organism from straw.

A second denitrifying organism was found in horse manure by Schirokikh early in 1896, while more recently an organism of this class was found in cow manure by Ampola and Garino.

Considerable progress in our knowledge of the denitrifying ferments in soil has been made by Ewell in the Division of Chemistry, Department of Agriculture, in

investigations not yet published. He has separated and begun the study of three organisms that rapidly destroy nitrates with the formation of free nitrogen. One was obtained from a sample of soil, another one from pig manure and the third one from hen manure. The first two belong to the class of organisms which liquefy gelatine and produce a green or yellowish green fluorescent pigment. They belong to the same or closely related species. For comparison of these organisms, cultures of all similar organisms obtainable have been procured from the bacteriological laboratories of the United States Marine Hospital Service and of the Surgeon-General of the Army. The organisms thus far examined in regard to this property are the following: Two cultures from different sources of *B. pyocyaneus*, two of *B. fluorescens liquefaciens* and one each of *B. pyocyaneus*, *B. pyocyaneus D.* and *B. pyocyaneus pericarditidis*.

From the description given by Schirokikh of the organism found by him in horse manure it would appear that it is also of this class.

The study of the organisms isolated by Ewell will be continued and reported at the proper time; the investigation is to be extended to include soils of the various types, the feces of all the domestic animals, and various fodders, etc., in order that we may develop as fully as possible our knowledge of the nature and habitat of all organisms possessing the power to reduce nitrates with the liberation of free nitrogen.

Numerous bottles of nitragin have been received in this country, and I believe experiments are now in progress in many of our experiment stations in its use. The practical demonstrations which have been made, however, of its utility have been made at European stations, and many of the results which have been obtained in this country have not yet been published. Many interesting contributions to the literature of the subject will doubtless come from our own stations in the near future. Important work has already been done in studying the nodules of leguminous plants in many of our stations, especially in those of Massachusetts, Louisiana and Illinois.

(*To be concluded.*)

H. W. WILEY.

DEPARTMENT OF AGRICULTURE,
WASHINGTON, D. C.

THE AMERICAN SOCIETY OF NATURALISTS.

THE annual meeting of the 'Naturalists' and 'Affiliated Scientific Societies' was held at Cornell University, Ithaca, New York, December 28, 29, 30, 1897. The mild weather and attractive surroundings, together with the unbounded hospitality of the people of Ithaca and an excellent program and large attendance, combined to make the meeting more than usually successful.

In the absence of the President, Professor Whitman, of the University of Chicago, the chair was occupied by Professor S. F. Clarke, of Williams College, one of the founders of the Society. After listening to the Report of the Treasurer, action was taken on certain items of business.

Communications from the President of Columbia University, the President of the American Museum of Natural History, and the Secretary of the New York Academy of Sciences, inviting the Society to hold its next meeting in New York City, were read and referred to the Executive Committee. The Society subsequently decided to accept the invitations from New York.

It was reported that President McKinley was about to appoint a commissioner to serve in the place of Mr. John J. Brice and, in view of the present deplorable condition of the scientific work of the Commission, the following resolutions were unanimously adopted:

"*Resolved*, That the American Society of Naturalists, as representatives of the principal scientific and educational interests of this country, unanimously express to the President and Congress of the United States their sentiment that the Commissioner of Fish and Fisheries should, according to the law of 1888, governing his appointment, be 'a person of proved scientific and practical acquaintance with the fish and fisheries of the coast.'

"*Resolved*, That it is of the utmost importance that the Fish Commission, as one of the most useful scientific institutions of the government, should be free from political influence and should be administered with the highest degree of scientific efficiency by an experienced officer."

It was then voted that Professor H. F. Osborn, of Columbia University, be a delegate to convey the resolutions of the Society to the President of the United States, and the members were asked to urge their Congressmen to prevent the appointment of any person unfitted for the place. The keen interest that was manifest in the discussion is a guarantee to Mr. McKinley that if his appointment is in accord with the spirit of the law he will gain the active support of scientific men throughout the country.

Professor T. H. Morgan stated that the 'American Tables' at Naples were quite inadequate to the needs of American students, and that were it not for the unlimited generosity of Professor Dohrn many Americans could not have availed themselves of the privileges of the Zoological Station. Professor Osborn said that a friend of Columbia University had offered two hundred and fifty dollars towards the five hundred necessary for the support of an additional table, and Professor John B. Smith moved that the Society appropriate one hundred dollars to be added to that already in the hands of Professor Osborn. It was so voted. It was also voted that that fifty dollars be appropriated for the continuance of the 'Naturalists' Table' at Woods Holl.

An amendment to the constitution, providing for the extension of the territory in which the Society may meet, was actively discussed, but failed of the number of votes necessary for its passage. The members then listened to the annual discussion on 'The Biological Problems of To-day:'

Paleontology.	Professor H. F. Osborn, Columbia University.
Botany.	Professor Wm. Trelease, Missouri Botanic Gardens.
Anatomy.	Professor Burt G. Wilder, Cornell University.
Psychology.	Professor J. McKeen Cattell, Columbia University.
Physiology.	Professor Jacques Loeb, University of Chicago.
Developmental Mechanics.	Professor T. H. Morgan, Bryn Mawr College.
Morphogenesis.	Professor Charles B. Davenport, Harvard University.

Each participant was limited to ten minutes and the papers were short and to the point. They will be printed in full in this JOURNAL at an early date. Special papers were presented by Professors Osborn, Williams and Wilder.

The following officers were elected for 1898:

President.—H. P. Bowditch, Harvard Medical School.

Vice-Presidents.—Professor Wm. James, Harvard University; Professor S. H. Gage, Cornell University; Professor H. S. Williams, Yale University.

Secretary.—Professor H. C. Bumpus, Brown University.

Treasurer.—Professor John B. Smith, Rutgers College.

Executive Committee.—Professor J. P. McMurrich, University of Michigan; Professor E. G. Conklin, University of Pennsylvania.

The annual dinner, given at Cascadilla Place, was a thoroughly enjoyable occasion. Professor Osborn presided in the absence of Professor Whitman, who, being unavoidably detained, was unable to give the address on 'Some of the Functions and Features of a Biological Station,' that he had

prepared. It will be published in an early issue of SCIENCE.

H. C. BUMPUS,
Secretary.

BROWN UNIVERSITY, PROVIDENCE, R. I.

SCIENTIFIC NOTES AND NEWS.

THE meeting of the American Society of Naturalists at Ithaca, reported above, was unusually well attended, owing to the large number of affiliated societies meeting with it. In addition to the Physiological Society, the Morphological Society and the Psychological Association, which met last year at Boston, there was not only the Association of Anatomists, which last year postponed its meeting till the spring, but there were also two new societies—the Association for Botanical Morphology and Physiology, and Section H., Anthropology, of the American Association. The proceedings of all these societies, which will be fully reported in this JOURNAL by the Secretaries, were crowded with excellent papers. The meeting at New York next winter will undoubtedly be the most important in the history of the American Society of Naturalists and affiliated societies.

THE Royal Society has received, through Professor Anderson Stuart, telegraphic information that the expedition sent out to bore a coral reef at Funafuti has returned to Sydney, having carried the bore down to 698 feet, without reaching the bed rock.

AT a meeting of the Board of Managers of the National Geographic Society on December 31, 1897, Alexander Graham Bell was elected President of the Society. This election fills the vacancy occasioned by the death of Mr. Gardiner G. Hubbard.

THE Parkin Prize of the Paris Academy of Sciences has been awarded to Dr. A. D. Waller, of London, for his investigations on the relations of nervous activity and carbon dioxide. The prize is of the value of about $600.

M. RAMBAUD, French Minister of Education, Senator, and professor of contemporary history at the Sorbonne, has been elected a member of the Academy of Moral Sciences, in the room of the late Duc d'Aumale.

THE Berlin Academy of Sciences has appropriated three thousand Marks for the publication of a map of the Arabian desert of Egypt.

THE office of Astronomer Royal of Ireland, and the professorship of astronomy in the University of Dublin, has been conferred upon Mr. C. J. Joly, fellow of Trinity College.

WILLIAM HARPER, Chief of the Bureau of Information of the Philadelphia Commercial Museums, has returned to Philadelphia after a trip around the world taken in the interest of the Museums.

THE death is announced of Dr. Friedrich A. T. Winnecke, who some years ago made important contributions to the astronomy of position at the observatories at Bonn, Pulkova and Karlsruhe. On the establishment of the University of Strassburg, at the end of the Franco-German War, he was made director of the observatory, but his health broke down, and since that time he has been unable to accomplish any scientific work.

WE regret also to record the deaths of the following men of science: M. Imbault Huart, the French Consul at Canton, at the age of forty years, who was a high authority on the languages and geography of the Far East, especially of Formosa, on which he published an elaborate work; Dr. Giacomo Sangalli, professor of pathological anatomy in the University of Pavia, and Senator of the Kingdom of Italy, aged 76; Dr. Franz Ritter von Schneider, professor of chemistry in the University of Vienna.

GROUND was formally broken for the Museum Building of the New York Botanical Garden by President Samuel MacMillan, of the Department of Public Parks, on December 31st, with a nickel-plated pick and shovel presented to him at the site for the purpose by Messrs. Parker and Parshley, of the John H. Parker Co., contractors, in the presence of Messrs. Fallows and Ward, representing Mr. R. W. Gibson the architect, and Dr. Britton, Mr. Henshaw and Mr. Nash, of the Garden staff, and others. Appropriate remarks were made by President MacMillan and by Dr. Britton. The contract for the construction and equipment of the Museum Building, Power House and minor buildings has been awarded by the

Commissioners of Parks to the John H. Parker Company for $347,019.00. The plans for the great range of horticultural houses have been completed, and specifications for them have been printed. We hope to publish illustrations and descriptions of these and of the Museum Building in an early issue. The sum of $15,000.00, in addition to the funds provided by the Act of Incorporation, has been made available for the building of portions of the driveway system. During the past season about 2,900 species of plants have been obtained, together with large quantities of Museum, Library and Herbarium material.

The trustees of the British Museum have decided to discontinue the opening of the exhibition galleries on week-day evenings from 8 to 10 p. m. after the close of the year, and, instead, to keep them open (in alternate sections) until 6 p. m. all the year round. The evening opening commenced in February, 1890, on the installation of the electric light, but the attendance has been too small to warrant the continuation. The arrangements for opening on Sunday afternoon have not been altered.

The schooner 'Prosper' has arrived at San Francisco with about 240 fur-seal skins from the Galapagos Islands. It is a pity that Ecuador has taken no steps to protect what is left of the once valuable rookeries on these islands, which, with proper care, might have been brought in time to a paying basis. Of course, every catch like that of the 'Prosper' lessens the possibility of so doing and increases the length of time it would require. The species, *Arctocephalus townsendi*, is only known to science through a few skulls obtained by Mr. Townsend some years ago when the seals were not on the rookeries.

The Secretary of the Treasury has issued regulations under the Act of Congress prohibiting the taking of seals by American citizens, except on the Pribyloff Islands, and forbidding the importation into this country of pelagic sealskins. The regulations provide that no sealskins, raw, dressed, dyed or otherwise manufactured, shall be admitted to entry in the United States, except there be attached to the invoice a certificate signed by the United States Consul at the place of exportation that said skins were not taken from seals killed within the waters mentioned in said act, specifying in detail the locality of such taking, whether on land or at sea, and also the person from whom said skins were purchased in their raw and dressed state, the date of such purchase and lot number. Consuls shall require satisfactory evidence of the truth of such facts by oath or otherwise before giving any such certificate.

A new laboratory for physical chemistry at the University of Leipzig was formally opened on January 3d, if the program was carried out.

Mr. John Milne writes to *Nature* that arrangements have been made for the establishment of horizontal pendulums, with photographic apparatus to record unfelt movements, at Toronto, Harvard, Philadelphia, Victoria, B. C., New Zealand (two), Batavia, Madras, Calcutta, Bombay, Mauritius, the Cape, Argentina, San Fernando and Kew, while a number of other stations are under consideration. Seismograms have already been received from Toronto. At his station on the Isle of Wight, for purposes of comparison, Mr. Milne has also two horizontal pendulums writing on smoked paper, and very shortly a Darwin bifilar pendulum is to be established. To this will be added later a von Rebeur-Paschwitz apparatus, with which type of apparatus Mr. Milne worked for many years in Japan.

In 1889 the late Francis B. Hayes placed all his property in trust, providing that at his death it might be willed to such charitable corporations as he might select. He made the Massachusetts Horticultural Society his residuary legatee, and as there was some doubt as to whether this could be regarded as a charitable organization the matter was brought before the Court. Judge Allen has decided that the bequest was permissible, and the Horticultural Society will receive $300,000, as well as $10,000 left to it directly.

The Massachusetts Board of Agriculture has authorized an inspection of the spread of the brown-tail moth, which was first discovered in Cambridge and Somerville last spring, and it has been found that it has spread greatly to

the northeast. The Board has no means at its disposal for exterminating the pest, but has notified the owners or managers of some 1,900 estates of the law of 1897, which says that "it shall be the duty of the owners and managers of premises infested with this moth to exert themselves persistently to confine and suppress it," and have furnished them with a bulletin describing the pest and giving directions for its destruction.

THE nomenclature of the new New York City parks, relative to which there has been much discussion, was fittingly determined at a recent meeting of the Park Commissioners by the selection of the following: Alexander Hamilton Park, John Jay Park, De Witt Clinton Park, William H. Seward Park and Hamilton Fish Park. It had been suggested, as we noted in a recent issue, that the name of the late W. A. Stiles, a former Park Commissioner, should be associated with one of the new pleasure grounds, but the precedent of naming a park in honor of any Park Commissioner was wisely deemed a bad one. The fostering care of science and art, and the distinguished services rendered the city and the nation by the eminent men whose names have been chosen, make the decision one which will meet with universal approval. All lovers of nature will be particularly gratified by the graceful recognition of De Witt Clinton.

THE Astley-Cooper prize of the value of £300, awarded biennally by Guy's Hospital, will again be given at the beginning of 1901, the subject being the 'Physiology of the Pancreas.'

THE United States Civil Service Commission announces that, on February 7, 1898, an examination will be held to establish an eligible register from which a selection may be made to fill a vacancy in the position of keeper of aquarium at the National Zoological Park at a salary of $75 per month. The examination will consist of a light educational test, together with practical questions on the habits, distribution and classification of fishes, including translations of descriptions of fishes from German and Latin into English.

THE Friday evening meetings of the Royal Institution will begin on January 21st at 9 p. m., when the Right Hon. Sir John Lubbock, Bart., M. P., will give a discourse on 'Buds and Stipules.' Succeeding discourses will probably be given by Professor C. Lloyd Morgan, Mr. Alan A. Campbell Swinton, Dr. John Hall Gladstone, Professor L. C. Miall, Captain Abney, Professor T. E. Thorpe, Mr. James Mansergh, the Very Rev. the Dean of Canterbury, Professor Dewar and others. To these meetings members and their friends only are admitted. Lord Rayleigh will deliver lectures after Easter.

THE fifth annual lecture course of the Linnæan Society of New York City, in coöperation with the American Museum of Natural History, will be given in the large lecture hall of the Museum, Seventy-seventh street and Eighth avenue, as follows:

January 6th, 'Cats and the Lands they Inhabit,' by DANIEL GIRAUD ELLIOT, F. R. S. E., Curator of Zoology, Field Columbian Museum. February 3d, 'From Vera Cruz to Mexico City,' by FRANK M. CHAPMAN, Assistant Curator, Vertebrate Zoology, American Museum of Natural History. March 17th, 'The Mammals of North America,' by ERNEST SETON THOMPSON; illustrated by views from nature and from original drawings by the lecturer. April 7th, 'Protective and Directive Coloration of Animals,' by C. HART MERRIAM, M. D., Chief of Biological Survey, U. S. Department of Agriculture.

THE Garden and Forest Publishing Company announce that with the last issue, which completes the tenth volume, the publication of *Garden and Forest* will be suspended. They state that "For ten years the experiment has been tried of publishing a weekly journal devoted to horticulture and forestry, absolutely free from all trade influences, and as good as it has been possible for us to make it. This experiment, which has cost a large amount of time and money, has shown conclusively that there are not persons enough in the United States interested in the subjects which have been presented in the columns of *Garden and Forest* to make a journal of its class and character self-supporting. It is useless to expend more time and money on a publication which cannot be made financially successful, and must, therefore, sooner or later cease to exist."

M. BRUNETIÈRE has retired from the editorship of the *Revue des deux Mondes*, the great

French literary journal. This is a matter of some scientific interest, as M. Brunetière had changed the journal from a liberal to a clerical organ, and while professing to use scientific methods in literary criticism had adopted an attitude somewhat hostile to modern science.

Professor O. Taschenberg has retired from the editorship of *Die Natur* and has been succeeded by Professor Willi Ule. The journal, published weekly by the Schwetschke'sche Verlag at Halle, was founded forty-six years ago, under the editorship of Dr. Otto Ule and Dr. Karl Müller. It maintains an excellent standard of popular science, being neither technical nor trivial.

The publication department of the *Progrés Medicale* offers the complete works of Charcot, in thirteen vols. for 50 fr., reduced from 188 fr.

Messrs. Studer Bros. announce 'Chapters on the Natural History of the United States,' by Dr. R. W. Shufeldt. The pictures are reproduced from a series of photographs, made from life by the author.

A new monthly periodical, *Archives de Médicine des Enfants* will hereafter be edited by Dr. J. Comby and published by Masson, Paris.

Mr. Jonas Stadling, who contributed to the November *Century* an account of Andrée's expedition, sends to the January number a facsimile of a message from Andrée, sent by the aëronaut by carrier pigeon.

In *Nature* for December 7th an article on the beaver park of Sir Edmund Loder gives interesting information regarding the beavers of Sweden. It appears that they are mainly confined to the Stifts of Christiania and Christiansand, although a few remain in Bratsberg Amt and Slavanger Amt. They feed on the bark of deciduous trees, not touching the firs. As they are unable to dam the swift streams of Sweden, they make their burrows at right angles to the bank, running inward and upward for some distance, so that when the rivers rise the beavers go higher up in their burrows. In 1880 there were about 60 animals left, but being protected they increased to 100 by 1883. Since 1894 a law has been passed protecting them for a period of ten years.

A skeleton of the moa, *Dinornis* or *Euryapterix emeus crassus*, the extinct giant bird of New Zealand, was purchased recently at auction in London by Dr. Hutchinson for 48 guineas. It is said that most of the skeletons exhibited in museums are made up from different species. The present specimen was set up by Captain F. W. Hutton, F.R.S.

The United States Coast and Geodetic Survey will send the steamship 'McArthur' to the waters of Alaska to make, when spring opens, a thorough survey of the coast, especially about the mouth of the Yukon River. A small steamer will also be taken to aid in the surveying work and to serve for the navigation of rivers too shallow for the 'McArthur.'

At the recent international congress of publishers, held at Brussels, a recommendation was made that is of special interest to men of science, and should be insisted upon by them in arrangements with their publishers. The resolution was to the effect that a mere new printing of a book should be called a *tirage*, and not a new edition, unless it has been revised by the author.

The metric system of linear measurement has now been in use in the English engine building works of Messrs. Williams & Robinson four years. Captain Sankey reports in the London *Engineer* that the draughtsmen are unanimously pleased with its working, and that the workmen, at first strongly opposed to its introduction, now greatly favor it. The manager finds it easier to teach the new than the old system.

At an extra meeting of the Chemical Society, London, held at Burlington-house on December 15th, Professor Francis R. Japp, F.R.S., delivered a memorial lecture in honor of the distinguished German chemist, Friedrich August Kekulé, whose death occurred last year. After giving a sketch of Kekulé's life, Professor Japp said, according to the report in the London *Times*, that his supreme merit lay in his contributions to theoretical chemistry. His greatest achievements in this department were the doctrine of the linking of atoms in terms of their valency, and, growing out of this, the theory of the structure of organic molecules, both in open-chain and in closed-chain compounds. These were not recondite theories, hidden

away in the depths of the science; on the contrary, they were organic chemistry itself, and learnt by students on their first introduction to the subject. The lecturer proceeded to give an account of the genesis of some of Kekulé's theories and their relation to the work of other investigators. His memoir on the benzene theory, which was referred to as the crowning achievement of the doctrine of the linking of atoms, was the most brilliant piece of scientific prediction to be found in the whole range of organic chemistry. What Kekulé wrote in 1865 had since been verified in every particular, and not only had the various substitution derivatives been discovered in the number and with the properties required by the theory, but various observations that appeared to contradict it had been proved erroneous. Moreover, it had shown itself capable of boundless development, and there seemed no limit to the fruitfulness of Kekulé's conception of closed chains. Even in the undeveloped state of the subject prior to this theory, the facts were apparently so intricate and so unconnected that few chemists could claim to have mastered them. The theory appeared; the previously unmarshalled facts fell into their proper places, and, further, it became possible to say whether in any given section of the subject the facts were complete or only fragmentary. The debt which both chemical sciences and chemical industry owed to Kekulé's benzene theory was incalculable. As regards the former, three-fourths of modern organic chemistry was directly or indirectly the product of the theory, and as to the latter the industries of the coal-tar colors and the artificial therapeutic agents in their present form and extension would be inconceivable without the inspiration and guidance of Kekulé's fertile idea. By the accuracy of his predictions he had done more to inspire chemists with a belief in the utility of legitimate hypotheses in chemistry, and had, therefore, done more for the deductive side of the science than almost any other investigator. His work stood preëminent as an example of the power of ideas. A formula, consisting of a few chemical symbols jotted down on paper and joined together by lines, has supplied work and inspiration for scientific chemists for an entire generation and afforded guidance to the most complex industry the world had yet known.

THE scientific work accomplished by the Prince of Monaco, in the *Hirondelle* up to 1889, and since then in the *Princesse Alice*, has developed so greatly that the last named yacht has been found too small for the proper carrying out of these researches. As we learn from *Industries and Iron*, a larger yacht will be built for the continuation of the work. It will be a fast vessel, propelled by engines of 1,000 indicated horse-power, and designed to ensure a speed of 12 knots. She has a length between perpendiculars of 225 feet, with 34 feet beam, a depth of 20 feet, and her tonnage is 1,270 tons. The hull is built of steel, divided into seven water-tight compartments extending the upper deck. The cabin accommodation will be extensive, there being separate cabins for the scientific staff and a large laboratory.

THE *British Central Africa Gazette* states that reports from the West Shiré and Ruo districts give reason to believe that rinderpest has made its appearance among the game in both those districts. Game is said to be dying in numbers in the Elephants' Marsh—one of the game preserves formed by the administration of the Protectorate for the purpose of preventing the extermination of wild animals in this part of Africa. Prompt measures, it is said, have been taken to endeavor to prevent the introduction of the disease into the Shiré Highlands..

UNIVERSITY AND EDUCATIONAL NEWS.

THE Executive Committee of the Board of Trustees of the New York City College have accepted the plans of the new buildings presented by Mr. George B. Post. The estimated cost is about $1,200,000. The plans include provision for a chapel with a seating capacity of over 2,000, a library that will hold 70,000 books, a museum of natural history, laboratories, etc. The building, which will be of the English Collegiate Gothic style of architecture, will stand on a high elevation. It will be on Convent Avenue, St. Nicholas Terrace and 138th and 140th streets.

MR. LEVI BARBOUR, of Detroit, one of the regents of Michigan University, has donated

$15,000 toward an art building for the university, providing a $100,000 building shall be erected on the campus within six years.

By the will of the late Susan S. Clark, of Hartford, Conn., just admitted to probate, Trinity College is to receive $10,000 for the support for two scholarships.

The library of the University of Missouri has received a gift of about 2,000 volumes, chiefly on physics and chemistry, from Dr. A. Linton, of St. Louis.

A Fellowship, to be called the Geoffrey Fellowship, of the value of £100 a year for three years, has been presented to Newnham College, Cambridge, and will be awarded in June, 1898. The Geoffrey Fellow will be required to reside at Newnham College, and to pursue independent study in some department of learning, letters or science.

The committee of the Charing-cross Hospital Medical School has passed the following resolution: "That the committee of the Charing-cross Hospital Medical School respectfully urges the government to introduce, early in the ensuing session, a bill on the lines of the London University Commission Bill, 1897. Further, the committee hopes that on this occasion the government will give sufficient time and support to the bill to insure its passing through both Houses of Parliament."

An election to the Isaac Newton studentship of Cambridge University will be held in the Lent term, 1898. The studentship, which is of the annual value of £200, is for the encouragement of study and research in astronomy (especially gravitational astronomy, but including other branches of astronomy and astronomical physics) and physical optics. The persons eligible are Bachelors of Arts of the University who will be under the age of 25 years on January 1, 1898.

The University of Zurich has 713 students, of whom as many as 333 are foreigners. 135 of these are from Russia. There are more women than men in the medical department.

The Quain professorship of physics in University College, London, will be vacant at the end of the present session by the resignation of Professor Carey Foster. Candidates for the chair should send their applications by Tuesday, March 1st. 'The Curators of Patronage' of the University of Edinburgh announce that candidates for the chair of moral philosophy, vacant by the death of Professor Henry Calderwood, must send in their applications not later than March 31st.

DISCUSSION AND CORRESPONDENCE.

WATER SURFACE TEMPERATURES OF LAKE TITICACA.

To the Editor of Science: A few observations of the temperature of the surface waters of Lake Titicaca, made during a recent trip across the lake, may be of interest to the readers of Science.

Lake Titicaca lies on the elevated plateau of Titicaca, partly in Peru and partly in Bolivia, at an altitude of 12,505 feet above sea-level. Its large size, its altitude, and the climatic conditions of the region in which it is situated, together with the historical associations connected with it, combine to make it in many respects the most interesting lake in the world. The following observations—unfortunately very incomplete—were made during the steamboat trip from Puno, situated on the Bay of Puno, at the western end of the lake, to Chililaya, a small village near the southern extremity of the lake. Chililaya, the landing place for passengers and freight going to La Paz, is about 100 miles from Puno, and 36 miles by carriage road from La Paz.

The steamer left Puno at 8 a. m., November 26th, and reached Chililaya at 7:30 p. m., the same day. At 8 a. m., before leaving the wharf at Puno, the air temperature was 56.0° and the water 60.9°. There were at that time scattering cirrus clouds, and a gentle breeze from N E. The air and water temperatures during the remainder of the day were as follows: 9 a. m., air, 50.0°; water, 59.5°. 10 a. m., air, 53.2°; water, 59.0°. 11 a. m., air, 51.8°; water, 57. 2°. 12m., air, 51.2°; water, 57.7°. 1 p. m., air, 50.9°; water, 57.9°. 2 p. m., air, 54.2°; water, 58.2°. 3 p. m., air, 54.8°; water, 58.3°. 4 p. m., air, 54.1°; water, 57.9°. 5 p. m., air, 49.8°; water, 57.9°. 6:15 p. m.,

air, 53.5° (in lee of land); water, 57.8°. The conditions of sky and wind during the day were a light to fresh breeze from NE, and scattering cirrus clouds or clear sky over the lake. These observations, incomplete as they are, are of some interest. The higher temperature of the water near shore, where the lake is shallow, and in the Bay of Puno, which is pretty well cut off from the main body of the lake; the slight diurnal variation of temperature, reaching a maximum at 3 p. m., and the prevailingly higher temperature of the water surface over that of the air, are facts that seem to be rather clearly indicated as far as this one set of observations is concerned.

On November 28th, during the return trip of the steamer, observations of air and water surface temperatures gave the following results: 7 a. m., air, 52.1°; water, 56.5°. 8 a. m., air, 51.1°; water, 57.0°. 9 a. m., air, 51.9°; water, 57.1°. 10 a. m., air, 56.7°; water, 57.7°. 11 a. m., air, 52.5°; water, 58.2°. 12 m., air, 55.1°; water, 57.9. 1 p. m. (outside Bay of Puno), air, 57.7°; water, 59.5°. 2 p. m. (in Bay of Puno), air, 62.1°; water, 60.4°. 5 p. m. (at Puno mole), air, 49.0°; water, 62.0°. The meteorological conditions during the day were an overcast sky (cirro-stratus) and light southeast wind, or calm, till 11 a. m., when the wind changed to northeast, and gradually increased, with increasing cloudiness (alto-stratus and cumulo-nimbus) until it reached about twenty-five miles an hour. The sky remained dark and threatening during the rest of the afternoon, but the wind died down soon after 4 p. m. The water temperatures show the diurnal increase up to 11 a. m., after which hour, owing probably to the increasing cloudiness and the change in wind direction, there came a fall in temperature in the open lake. In the Bay of Puno, as on the outward trip, the temperatures were higher than in the main body of the lake. Throughout the day, except at 2 p. m., the air temperature was below that of the water.

The clouds noted during the two trips across the lake were also interesting. On the first day, during the whole of which the sun was shining brightly, there was a very active growth of cumulus clouds over the mountains bordering on the lake. These clouds were first noted at 8:15 a. m. It was very noticeable, during the entire day, that the cumuli were over the land, where the rapid warming of the surface gave rise to ascending currents of air, and not over the lake, the sky over the water remaining clear, or showing light cirrus only. This phenomenon is very commonly noted in the neighborhood of large bodies of water, as in the case of our own Great Lakes. Another fact of interest was that the cumuli were better developed over the eastern shore of the lake, where the mountains are higher, than over the western shore, which is lower. During the morning the cumuli developed rapidly into cumulo-nimbus clouds, whose tops, blown southwestward over the lake, soon broke off from their bases, and dissolved as they descended to lower levels, being no more supported by ascending currents of air from below. About 2 p. m. the cumuli reached their greatest development, and at 4:30 began rapidly to dissolve into long lines of degraded cumuli. The height of the latter at 5 p. m., determined by reference to the heights of the Bolivian Andes behind them, was about 15,000 feet above sea level. It was noted that there was a considerable development of cirrus over the cumuli during the morning hours of this day, thus indicating a relation between the cumulus, formed at a lower level in the ascending current, and the cirrus, formed at a second higher level. At this second level, as explained by Abercromby, the diminished amount of vapor which the ascending current contains after the formation of the cumulus reaches its second condensation point, and a second layer of cloud, the cirrus, is formed.

As yet no careful study has been made of the meteorology of the Lake Titicaca district, and nothing definite can be said as to the influence of this body of water upon the climate of the surrounding country. There can, however, be little doubt that the lake must modify this climate to a considerable extent, although the surrounding mountains would confine this influence to the immediate vicinity of this lake.

R. DEC. WARD.

HARVARD COLLEGE OBSERVATORY,
AREQUIPA, PERU, December 1, 1897.

ZIRKELITE—A QUESTION OF PRIORITY.

In the *Mineralogical Magazine*, Vol. XI., pp. 86–88 (read June 18, 1895) is described a new mineral containing zirconium, titanium, lime, iron, etc., under the name of Zirkelite. This paper was prepared by my friend Dr. E. Hussak and Mr. G. T. Prior.

Later Mr. Prior (l. c., pp. 180–183, Read Nov. 17, 1896) published an analysis of the same mineral.

I wish to protest against the use of the name Zirkelite for this mineral on the ground of the prior use of it to designate a commonly occurring rock belonging to the basaltic family.

When two subjects are so intimately connected as mineralogy and petrography it does not seem to be for the interest of science that names should be duplicated in them. So true is this that I abandoned the name Rosenbuschite, which I had given to a class of rocks in honor of Professor Rosenbusch, because only a few weeks previously it had been employed to designate a new mineral.

The term Zirkelite was used by me in 1887, or seven years before it was taken by Messrs. Hussak and Prior. (See Preliminary Description of the Perioditites, Gabbros, Diabases and Andesites of Minnesota. Bulletin No. 2, Geological Survey of Minnesota, 1887, pp. 30–32.) It was used to designate the commonly occurring altered conditions of basaltic glassy lavas which are often called diabase glass, etc. Zirkelite occurs forming the entire mass of thin dikes, and the exterior parts of many dikes of diabase and melaphyr, as well as the surface of old lava flows like the melaphyrs and diabases of Lake Superior, Newfoundland and elsewhere. Zirkelite holds the same relation to tachylite that diabase and melaphyr do to basalt, *i. e.*, an older and altered type. The macroscopic and microscopic characters of this rock were given in the locality cited above.

The term Zirkelite was again used in the same way in my Report to the Geological Survey of Michigan for 1891–1892 (1893, pp. 30, 97, 138, etc.).

It was also published in my classification of rocks given in the Catalogue of the Michigan College of Mines (Michigan Mining School) 1891–1892, p. 104; 1892–1894, Table XI.; 1894–1896, Table XI.

Further, the term Zirkelite is defined in accordance with my usage in Loewinson-Lessing's Petrographisches Lexikon, 1893, p. 252; and accounts of it are given in the Neues Jahrbuch für Mineralogie, 1893, II., p. 292, and in Kemp's Handbook of Rocks, 1896, p. 170.

M. E. Wadsworth.
Michigan College of Mines,
Houghton, Mich., December 17, 1897.

SCIENTIFIC LITERATURE.

Catalogus Mammalium tam viventium quam fossilium. Dr. E. L. Trouessart. New Ed. Fascic. II., Carnivora, Pinnipedia, Rodentia (Protrogomorpha and Sciuromorpha), pp. 219–452, June, 1897. Fascic. III., Rodentia (concluded), pp. 453–664, Oct., 1897. Berlin, R. Friedländer und Sohn. Price, $2.50 each part.

The second and third parts of Trouessart's 'Catalogue of Mammals, living and fossil,' have come to hand and carry the work through the Carnivora and Rodentia. These parts are less satisfactory than the first, and cannot be said to represent the present state of knowledge of the groups treated, particularly with respect to American forms. Among the latter many synonyms are accorded full specific rank, many good species are degraded to synonymy, and many forms are transposed in a manner that shows an absence of appreciation of their affinities. And when it comes to the geographic distribution of American species the most astonishing inaccuracies creep in, as might be expected.

In matters of nomenclature Dr. Trouessart seems to be a law unto himself, and consistency does not seem to be one of his canons. In using Brisson he quotes the pre-Linnæan edition (1756), which has no status in nomenclature, instead of the edition of 1762; while in quoting Linnæus he takes the opposite course and uses the 12th edition (1766) instead of the 10th (1758), which is accepted the world over as marking the beginning of Zoological nomenclature. With respect to Brisson's genera it will be interesting to know what rules, if any, led to the adoption of *Hydrochœrus* and the re-

jection of *Odobænus*, *Glis** and others. If all had been rejected his course would have had the merit of consistency and would be defensible. The generic name *Trichechus* is erroneously applied to the Walrus instead of the Manatee.

Dr. Trouessart is a most diligent searcher of the literature and is to be congratulated on the freedom of his catalogue from omissions. Most of the errors here pointed out are such as are bound to creep in in an undertaking of this character and magnitude, and the reviewer wishes it understood that in calling attention to them he has not done so in a spirit of criticism, but for the purpose of rendering the work more useful.

The authority for the generic name *Bassariscus* is Coues, 1887, not 'Rhoads, 1894.' The genus *Wagneria* Jentink, 1886, cannot stand. It is not only the same as *Bassariscus*, but is preoccupied.

Thalassarctos Gray, 1825, is antedated by *Thalarctos* of the same author and based on the same animal.

Lyncus Gray, 1825 (first printed *Lynceus* by Gray in 1821), is antedated by *Lynx* Kerr, 1792.

The name *Ictis* Kaup, adopted for a subgenus of Weasels, is preoccupied by *Ictis* Schinz, 1824, for which reason *Arctogale* Kaup will have to stand for the Weasels. This I have already published in SCIENCE (Vol. V., p. 302, Feb. 19, 1897); and since *Arctogale* Peters, 1864, is preoccupied by *Arctogale* Kaup, 1829, I proposed the new name *Arctogalidia* for the palm civets, of which *Viverra trivirgata* is the type (see SCIENCE as above).

Ursus piscator Pucheran, 1855, and *U. beringiana* Middendorff, 1851, given as forms of *U. arctos*, are based on the same animal.

Ursus emmonsi Dall, given as a 'variety' of *U. americanus*, is certainly a most distinct species.

* In the case of *Glis* it is stated in a footnote that the genus cannot be admitted because Linnæus had previously instituted the order *Glires*, and because Brisson did not use binomial nomenclature. The first reason is trivial and not in accord with any code of nomenclature; the second, if considered a valid objection by the author, should have caused him to reject *Hydrochœrus* also.

A most unfortunate slip is the reintroduction of Peale's generic name *Cricetodipus* (a synonym of *Perognathus*) for the Kangaroo rats of the genus *Perodipus*, in accordance with an ill-advised suggestion from Mr. Rhoads. But Mr. Rhoads carefully abstained from giving Peale's measurements of his type specimen, which prove beyond question that the animal could not have been a Kangaroo rat. The hind foot measured '$\frac{8}{10}$ inch'—a trifle less than 20.5 mm., which agrees with young specimens of *Perognathus* from the plains of the Columbia, in Oregon and Washington. A nursing young Kangaroo rat (*Perodipus columbianus*), from the same region, has a hind foot measuring 36 mm. and a total length more than double that given by Peale for his *Cricetodipus*.

Among the 12 Kangaroo rats of the genus *Dipodomys* given full specific rank, one (*similis*) is a synonym (of *simiolus*) and three (*ambiguus*, *simiolus* and *parvus*) are subspecies (of *merriami* Mearns). In the sequence given, these subspecies are not only accorded specific rank, but with one exception are removed from the forms to which they are most closely related and placed after members of widely different groups. Similarly, the large *Dipodomys spectabilis*, with its long tail-brush of pure white, is separated from its nearest ally, *D. deserti*, by a group of small dark-tailed forms.

Under the genus *Peromyscus*, comprising the American white-footed mice, the mixture of species and subspecies fairly takes one's breath away. The same is true in less degree of *Microtus* and of numerous other genera throughout the Catalogue.

Sciuropterus volans is given as the name of the European Flying Squirrel and *S. voluncella* as that of the American. This, while in accordance with former usage, is unfortunate since the *Mus volans* of Linnæus, 1766, is the Flying Squirrel of Virginia, as shown by Jordan and Bangs.

Under *Sciurus douglasi* five synonyms are raised to the rank of 'varieties.'

Under *Sciurus aberti*, *S. castanotus* [= *castanonotus*] Baird and *S. durangi* Thomas are given as subspecies. The former is a synonym; the latter a distinct species.

Under *Sciurus arizonensis* are included as subspecies the hardly distinct *huachuca* of Allen

and several widely different species, as *S. collixi* Richardson, *S. hypopyrrhus* Wagler and others. A curious freak in nomenclature is illustrated by this series, the majority of the 'subspecies' included under *arizonensis* antedating it by many years!

Coming to the Chipmunks, the author abandons his own earlier and, in the reviewer's judgment, excellent division of the group into *Tamias* and *Eutamias* and lumps them all under the former name. In arranging the species and subspecies of this perplexing group it is no wonder he is somewhat mixed, and that the forms are distributed without regard to their affinities. Thus *pricei*, at most a subspecies of *merriami*, is given full specific rank and placed between *townsendi* and *macrorhabdotes*. The latter, instead of ranking as a species, should stand as a synonym of *quadrimaculatus*.

The Spermophiles of the *lateralis* group (subgenus *Callospermophilus* Merriam) are placed in the genus *Tamias*, with which they have no close affinity.

Spermophilus sonoriensis, a subspecies of *tereticaudus*, is placed in a different subgenus! And *tereticaudus* and the closely related *neglectus* are wrongly referred to the subgenus *Ictidomys*.

In many instances Dr. Trouessart adopts the oldest generic name, as *Cœndu* for *Synetheres*; *Ochotona* for *Lagomys*, and so on; but in many cases he fails to do this. Thus,

Cœlogenus F. Cuvier, 1807, is antedated by *Agouti* Lacépède, 1799.

Lagostomus Brookes, 1829, is antedated by *Vizcacia* Schinz, 1824.

Myoxus Schreber, 1782, is antedated by *Glis* Brisson, 1762.

Platycercomys Brandt, 1844, is antedated by *Pygeretmus* Gloger, 1841.

Scirtomys Brandt, 1844, is antedated by *Scarturus* Gloger, 1841.

He uses also many preoccupied names. Among these are:

Arctogale Peters, 1864; replaced by *Arctogalidia* Merriam, 1897.

Echiothrix Gray, 1867; replaced by *Craurothrix* Thomas, 1896.

Hydrolagus Gray, 1867; replaced by *Limnolagus* Mearns, 1897.

Ictis Kaup, 1829; replaced by *Arctogale* Kaup, 1829.

Macrorhinus F. Cuvier, 1826; replaced by *Mirounga* Gray, 1827.

Wagneria Jentink, 1886; replaced by *Bassariscus* Coues, 1887.

The authority for *Tylonyx*, given as a synonym under *Dicrostonyx*, should be Schulze instead of 'Huth.'

Dr. Trouessart is not one of those who regards as sacred the original spelling of generic names. On the contrary, he accepts amended names in preference to the originals and in so doing operates at both ends, changing *Pithecheir* to *Pithecheirus* and *Endecapleura* to *Hendecapleura!*

A number of generic names are given erroneous dates. For instance:

Acomys	dates	from	1838;	not	1840.
Alticola	"	"	1881;	"	1884.
Ctenodactylus	"	"	1830;	"	1828.
Dolichotis	"	"	1819;	"	1822.
Graphiurus	"	"	1838;	"	1829.
Heterocephalus	"	"	1842;	"	1834.
Nyctocleptes	"	"	1832;	"	1835.
Rhombomys	"	"	1841;	"	1843.
Tachyoryctes	"	"	1835;	"	1834.

Under *Echimys* and the amended form *Echinomys* the authorities and dates are badly mixed.

In the case of family names the rule of priority is not always followed. For instance, '*Lagostomidæ* Bonaparte 1837' is antedated by *Chinchillidæ* Bennett 1833; and *Cœndidæ* Trouessart is antedated by *Erethizontidæ* Thomas.

Perhaps the oddest error in the Catalogue is the transposition of the Trinidad Opossum, *Thylamys carri* Allen and Chapman, to the Rodent genus *Tylomys* Peters!

The subfamily heading *Murinæ* is omitted, apparently by accident, and the resulting arrangement as printed puts *Mus* as a subgenus of *Otomys!*

A single new subgenus, *Microlagus*, is named. It is based on *Lepus cinerascens* Allen, a form whose relationship with *L. trowbridgii* is so exceedingly close that it is probably only subspecifically separable, and yet *L. trowbridgii* is placed in a separate subgenus (*Sylvilagus* Gray)!

A curious instance of persistent misspelling is the repeated occurrence of Vernon Bailey's name as Bayley, and of specific names based

thereon as *bayleyi*. Similarly *Reithrodontomys lacei* is spelled *lacyi*.

In dividing the work into parts it is a pity the publishers did not end the second part with the Carnivora instead of including the first 63 pages of the Rodentia. In binding by orders—the most convenient form for most uses—the volume on the Rodentia will have no title-page in front, but has one for the matter posterior to the 63d page, where the 3d fasciculus begins (page 453 of the whole Catalogue).

The reviewer is indebted to Dr. T S. Palmer for calling his attention to a number of the errors in generic names and dates.

In two instances Trouessart imposes new names on forms distinguished but not named by previous authors, and in both instances modestly but wrongly credits the name to the previous author instead of himself. The cases in point are *Vespertilio gryphus septentrionalis*, attributed to Harrison Allen, and [*Mus*] *sylvaticus* var. *noveboracensis*, attributed to Erxleben, and placed as a synonym of *Peromyscus leucopus*.

The three parts now published comprise the Primates, Chiroptera, Insectivora, Carnivora and Rodentia and contain 760 genera and 4,085 species. Of these, 288 genera and 1,900 species are included in the single order Rodentia.

The Catalogue, in spite of its inherent imperfections, is an extremely useful document and must be at the elbow of every student of mammals.

C. HART MERRIAM.

Guide to the genera and classification of the North American Orthoptera found north of Mexico. By SAMUEL HUBBARD SCUDDER. Cambridge, Mass., Edward W. Wheeler. 1897. Pp. 89. Price, $1.00.

Dr. Scudder began his entomological studies with the Orthoptera, and is still at work elaborating the sub-families, genera and species with reference to a general work on the classification of the order. The little book before us is designed to serve as a Prodomus of the work, which we hope may be completed at a no distant day. As such it will be of great service to the student, since the families, subfamilies and genera are tersely and yet fully described. Besides these diagnoses there are elaborate tables for the determination of the families, sub-families and genera; the species not being mentioned.

In addition to the general bibliographical notes, those devoted to the families and the list of the literature are full and presumably exhaustive. The index appears also to be complete. The paper and printing are unexceptional.

It will be seen that the book will be indispensable to the student, as there is nothing like it in our entomological literature. That it has been prepared with thoroughness and care goes without saying. When will the time come when we shall have similar exhaustive manuals of the other orders of insects.

A. S. PACKARD.

Les Ballons-Sondes de MM. Hermite et Besançon et les Ascensions Internationales. Par WILFRID DE FONVIELLE. Bibliothèque des Actualités Scientifiques. Paris, Gauthier-Villars. 1898. 18mo. Pp. 112. Figs. 27.

This brochure by my colleague, the Secretary of the Aëronautical Commission, is timely, since it is the first complete account of an important investigation in Europe. M. de Fonvielle is well fitted to write on the subject, for he is not only a distinguished aëronaut and the author of several books on ballooning, but since their inception he has been an advocate of 'ballons-sondes,' or 'ballons perdus,' as formerly they were derisively named.

When one of these exploring balloons, set free by MM. Hermite and Besançon, in November, 1892, lost its buoyancy and fell to the earth there was obtained for the first time, from its minimum barometer and thermometer, the greatest height and the lowest temperature which had been reached. Fourteen of these small balloons having envelopes, generally of paper, filled with illuminating gas were liberated from Paris and most of them were recovered with their instruments recording the extremes of height and cold. MM. Hermite and Besançon, therefore, were encouraged to continue the exploration of the upper air with larger balloons made of goldbeaters' skin or of special silk, which they called *Aërophiles*. These carried continuously recording barom-

eters and thermometers of Richard's construction, and in March, 1898, records were obtained 49,000 feet above the earth. In 1894 the Berlin Aëronautical Society began similar explorations in connection with manned balloons, and in September the exploring balloon *Cirrus* rose 60,000 feet and recorded photographically a temperature 90° Fahrenheit below zero. In December of the same year Berson, of Berlin, ascended alone 30,000 feet, and, at the highest level ever reached by man, observed a temperature 54° Fahrenheit below zero.

Efforts were now made to secure international cooperation, and the International Meteorological Conference which was held at Paris in September, 1896, furnished the opportunity to M. de Fonvielle. As stated in SCIENCE of January 1, 1897, simultaneous flights of manned and exploring balloons were recommended, and in consequence of the successful experiments with kites lifting self-recording instruments at Blue Hill this method of studying the lower air was advised. A commission was appointed to execute these resolutions, consisting of Messrs. Hergesell (President), of Strassburg; de Fonvielle (Secretary) and Hermite, of Paris; Pomortzeff, of St. Petersburg; Erk, of Munich; Assmann, of Berlin, and Rotch, of Boston. In the first international flight of 'ballons-sondes' on November 14, 1896, balloons were despatched from Paris, Strassburg, Berlin and St. Petersburg, but only the *Aërophile* from Paris reached a great altitude. Three simultaneous flights were made the past year, and the results of these and subsequent ones will certainly elucidate the conditions prevailing through a large extent of the upper air at much greater heights than can be reached by human beings. With these balloons only the barometric pressure and the air temperature are recorded, but after several attempts to obtain samples of the air at great heights this was finally accomplished with the apparatus of Cailletet carried by the *Aërophile*.

The chapter on the theory of a ballon-sonde, and the effect of temperature on the height to which one will rise, presents simply and clearly some important facts and formulæ. In closing this review it may be well to point out a few typographical errors. On pages 16 and 17 the words 'en papier' evidently should be omitted from the heading of the table, since balloons of goldbeaters' skin are included; in the same table the date 1862 should be 1892 and 'température maxima' should be 'température minima;' in the heading of the table on pages 88 and 89 the words 'en soie spéciale' should be omitted for the reason stated above.

It is proposed to hold a meeting of the International Aëronautical Commission next February, to consider plans for a more extended exploration of the atmosphere. As yet exploring balloons have not been employed in the United States, but the development of the kite in this country has proved it to be the best agent for studying the meteorological conditions of the lower ten thousand feet of free air at definitely determined heights. In fact, the records of temperature and humidity obtained with kites 11,086 feet above Blue Hill probably exceed in altitude any balloon observations on this side of the Atlantic, while the proposed use of kites by the Weather Bureau to obtain data for daily synoptic charts of the conditions a mile above the earth's surface may result in improving the weather forecasts.

A. Lawrence Rotch.

Volcanoes of North America: A Reading Lesson for Students of Geography and Geology. By Israel C. Russell, Professor of Geology, University of Michigan; author of 'Lakes of North America,' 'Glaciers of North America,' etc. New York, The Macmillan Co. 1897. 8vo. Pp. xiv + 346. Price, $4.00.

In giving to the world a companion volume to his Lakes, and Glaciers, of North America, Professor Russell has laid under renewed obligation both the geological student and the general reader. He is eminently fitted for the discussion of his present theme. His own travels and explorations have made him familiar with the eruptive phenomena of North America, through a wide range of latitude and longitude, and in manifold variety of type—from the Mesozoic trap sheets of New Jersey, to the majestic snow-clad cone of Rainier; from the craters of the Mono valley, to the widespread stratum of volcanic dust in the valley of the Yukon. To the knowledge gained by personal

observation he has added an extensive and critical acquaintance with the varied literature of the subject.

The book opens with a general discussion of the characteristics of volcanoes, in which the various types of eruption are illustrated by the classical examples of Stromboli, Vesuvius, Krakatoa, the Hawaiian volcanoes and the colossal lava sheets of the Deccan and the Columbia valley. A description of the gaseous, liquid and solid ejecta of volcanoes is followed by a discussion of the form and structure of volcanic cones and necks. Next are described the characteristic types of subterranean intrusions —dikes, sheets, plugs, laccolites and subtuberant mountains. The opening chapter closes with a brief discussion of the characteristics of igneous rocks. A brief and popular petrological section is by no means an easy thing to write. The requirement of perfect accuracy in brief and non-technical language is somewhat like the pious old woman's order on her bookseller for a very small Bible with very coarse print. The following statements are inaccurate and confusing: "If fused slag is cooled quickly, crystals are not developed, but the mass has a glassy or stony structure" (p. 68); "if solidification takes place at this stage [after formation of minute crystals floating in the still fused material], the ground mass becomes a glass or felsite" (p. 112); "if the cooling is rapid, a crystalline glass is produced" (p. 114). The application of the name basalt to the coarsely crystalline rock of the Palisades involves an extension of the meaning of the word unwarrantable even in a brief and popular discussion. The statement that trachyte is normally dark colored is certainly misleading. With Dana and others, Professor Russell holds that some granites are truly metamorphic rocks. The tendency at the present time is to derive gneisses from granites rather than granites from gneisses; but we believe there is truth in both views.

The main part of the book, as implied in the title, is occupied by the description of the active and recently extinct volcanoes of North America; and the reader cannot fail to be interested in the great variety of volcanic phenomena so clearly described in its attractive pages. The eruption of Coseguina in 1835 almost rivals in tremendous explosiveness that of Krakatoa in 1883. In Mount Taylor and its companions are seen beautiful examples of volcanic necks. The volcanoes of the Mono valley include a remarkable variety of volcanic phenomena; and the pages devoted to their description, bright with the vividness of personal observation, are among the most fascinating in the book. In Crater Lake we have a magnificent example of a caldera formed by the ingulfing of a volcanic cone. The reader will readily sympathize with the author's enthusiasm over the majestic beauty of the snowy cones that dominate the Cascade Range. In the Columbia lava sheet we have the result of colossal fissure eruptions rivaled only by those of the Deccan. The Spanish Peaks are beautiful examples of volcanoes dissected by erosion. In Shishaldin we see a volcanic cone, the symmetry of whose graceful, slightly concave lines rivals the beauty of Fusiyama. In Bogosloff we have apparently a shapeless mass formed by the sudden chilling of highly viscid lava erupted beneath the sea.

From the description of the volcanic phenomena shown in North America the author returns to the discussion of volcanoes in general. The reader who has become familiar with such widely varied details is in position to appreciate the inductions which may be drawn from them in regard to the mechanism of volcanic eruption. Professor Russell adopts the view that the interior of the earth is solid, but potentially liquid at no great depth below the surface—a view which seems to harmonize the teachings of geology with those of physics. In common with Reyer, the author attributes the relief of pressure, which is the condition of local liquefaction, and consequently of eruption, to the formation of fissures. We are inclined to believe that the principal cause of such relief of pressure and consequent liquefaction is found in crustal elevation, as suggested by Archibald Geikie.* Professor Russell rightly connects igneous intrusions with volcanic eruptions, as different phases of the same process. A true and comprehensive theory of vulcanism must include all phases of eruption and intrusion.

*Text-book of Geology, 3d edition, p. 268.

Incidentally, we remark that it may well be questioned whether the theory of protuberant mountains, so beautifully illustrated in the Sundance Hills, is not unduly stretched in attempting to make it cover the Front Range of the Rockies in Colorado and Wyoming. Finding the essential condition of eruption in liquefaction by means of relief of pressure, Professor Russell makes the rôle of steam merely incidental. The action of steam is conspicuous enough in volcanic eruptions of the explosive type, but it cannot account for the phenomena of great fissure eruptions; and the two extreme types of eruption are so connected by fine gradations that the general cause must be identical throughout the whole series. In criticising the special form of the steam theory proposed by Shaler, the author justly protests against the enormous thickness of sediments postulated by that theory. Professor Russell holds the steam contained in lavas to be exclusively of superficial origin. This is undoubtedly true of a part of it, and probably of much the larger part. But the fluid cavities of plutonic rocks are proof of the existence of water vapor in magmas at great depth, and it appears probable that somewhat of this vapor may have been occluded in the originally molten mass of the globe. Professor Russell holds that volcanic activity increased through geologic time until the Tertiary, and that it is now declining. This conclusion seems to us not supported by adequate evidence. According to modern views of the mode of solidification of the globe, the reaction of its heated interior upon its surface could not have been very different in Cambrian time from what it is now. The apparent rarity and insignificance of volcanic phenomena in the earlier geological periods may well be explained as due to the destruction of the evidence by erosion and metamorphism, or its concealment beneath masses of superincumbent strata.

The closing chapter, on the life history of a volcanic mountain, is an exquisite piece of scientific description, in which picturesque imagination gives vividness without detracting from scientific accuracy. One incidental point, however, we should be disposed to criticise. We would not, indeed, contradict the statement that it is *possible* that the aborigines, so artistically introduced to add a human interest to the pictures of natural scenery, were living in Tertiary time; but we do, nevertheless, consider such a supposition extremely improbable.

The book, so delightful and instructive, would have been made still better by more careful proof-reading. Several proper names are misspelled. We read *Atria del Cavallo*, instead of Atrio; *Mazana*, instead of Mazama; *Roichthofer*, instead of Richthofen; *Johnson-Lewis*, instead of Johnston-Lavis. In the note on page 74, in which the last name is thus misspelled, the reference to the *American Journal of Science* should be to Vol. 36. Typographical errors have rendered a few sentences ungrammatical or nearly unintelligible. The printers have also metamorphosed the young insects of Lake Mono into *lavæ*. The book is thoroughly attractive in its mechanical execution. Many of the pictures (mostly reproductions of photographs) are very beautiful.

Wm. North Rice.

SOCIETIES AND ACADEMIES.

NEW YORK ACADEMY OF SCIENCES—SECTION OF GEOLOGY, DECEMBER 20, 1897.

The first paper of the evening was by Mr. Arthur Hollick, entitled 'Recent Explorations for Prehistoric Implements in the Trenton Gravels, Trenton, N. J.' Dr. Hollick gave in his paper a summary of the present understanding of the artifacts found in the Trenton gravels, a more complete statement of which has already been published in Science for November 5, 1897. The second paper of the evening was by Professor J. F. Kemp, entitled 'Some Eruptive Rocks from the Black Hills.' Professor Kemp summarized the geological features and history of the Black Hills, and gave a bibliography of the works concerning these deposits. He then mentioned the occurrence of some Leucite-bearing rocks, in the northern part of the hills, similar in character to those which occur in but few other places in this country, as in Wyoming, Montana, Lower California and New Jersey, near the Franklin Furnace.

Richard E. Dodge,
Secretary.